NAVSHIPS 0994-009-6010

HANDBOOK
U. S. NAVY DIVING OPERATIONS

1 April 1974

Navy Department
Washington, D. C. 20350

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FOREWORD

NAVY DEPARTMENT
NAVAL SHIP SYSTEMS COMMAND
1 January 1971

The U. S. NAVY DIVING OPERATIONS HANDBOOK (NAVSHIPS 0994-009-6010) is issued as an addendum to the U. S. NAVY DIVING MANUAL (NAVSHIPS 0994-001-9010) of 1 March 1970.

PREFACE

As part of a continuing effort to maximize the availability of useful information for the fleet diver, the Office of The Supervisor of Diving has prepared this concise guide for the conduct of diving operations. Its content is based upon the most frequently used information from the Diving Manual and also introduces several new types of equipment and previously unpublished information on diving.

The Handbook has been designed for quick reference by the diver "on station" and features many new visual forms of information display. Throughout the Handbook illustrations, charts, and diagrams have been used in place of text matter. Rotary selector charts and calculators have been employed to condense information into compact forms and minimize the need for computations and cross-referencing to other sources of information. Color printing has been used to highlight and separate various sections. Areas, such as recompression treatment, have been reorganized to simplify instructions.

The construction of the Handbook reflects its place as an operational tool. It is printed on waterproof paper and is tab-indexed to facilitate quick referencing. Loose leaf binding permits the addition of new information in the rapidly changing field of diving technology.

The Handbook is organized in an analogous manner to an actual diving operation. Starting with Planning, a prime requisite to safe diving operations, it proceeds through the conduct of a dive to Emergency Procedures. Air and mixed gas diving techniques have been divided into two separate sections to improve ease of use.

The content and layout of the U. S. NAVY DIVING OPERATIONS HANDBOOK is based upon many comments, suggestions, and experiences of fleet divers. It is to this group, the working divers of the U. S. Naval Forces, that this book is dedicated. It is hoped that it will stand with the U. S. NAVY DIVING MANUAL as the most authoritative sources of diving information that can be prepared.

Eugene B. Mitchell
Captain, U. S. Navy
Supervisor of Diving

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ABOUT THIS BOOK

The book is printed on special waterproof, tear-resistant paper. Pages have been treated to accept lightly written felt-tip pen only. Do not use pencil, ball point pen, or grease pencil. Pages will wipe clean with a damp soapy rag. Pages are 8½" x 11" and are punched for standard GBC binding. Constructive criticism and recommendations for improvements of the handbook should be sent directly to:

Department of the Navy
Naval Ships Systems Command
Washington, D.C. 20360
Attn: Supervisor of Diving—OOC

SECTION 1—OPERATIONS PLANNING

INTRODUCTION

Safe diving operations start with careful planning. Think the job through beforehand. Plan carefully for the people and equipment that will be needed. Anticipate emergencies that may arise and have alternate plans.

The subjects contained in this section are designed to make the planning process easier and more thorough. Fill out the communications channels that may be needed for Emergency Assistance before starting. Define the mission as completely as possible by filling in the appropriate blanks. If there is a choice of diving technique, analyze the requirements and pick the procedure that is most appropriate. Diving beyond the limit shown in this section can only be authorized by a diving officer or higher authority where indicated.

Study personnel requirements and match skills of personnel to the jobs to be performed. Use the circular chart to assist in determining approximate diving time and personnel needs. Use the slots in the Operation Timetable to estimate time requirements.

Proper filing of diving logs is a mandatory requirement. The Handbook introduces the new OPNAV 9940/1 form which provides more information but minimizes the time required to fill out the form. Providing all the required information helps to make Navy diving safer for everyone.

PLAN AHEAD

EMERGENCY ASSISTANCE

EDU Duty Phone Number (202) 223-2790

RECOMPRESSION CHAMBER Location Contact Response Time	**HOSPITAL** Location Contact Response Time	**COMMUNICATIONS** Location Contact Response Time
AIR TRANSPORTATION Location Contact Response Time	**GAS SUPPLIES** Location Contact Response Time	**DEEP DIVING SYSTEM** Location Contact Response Time
DIVING MEDICAL OFFICER Location Contact Response Time	**SEA TRANSPORTATION** Location Contact Response Time	**DIVING UNITS** Location Contact Response Time

MISSION DEFINITION

PRIMARY TASK:

Characteristics of Sunken Object

Dimensions

Airweight

Floodable Volume

Disposition of Sunken Object

Specialized Hazards

Specialized Equipment/Material Required

Total Time Available

Geographic Location

Subsurface Conditions

Projected Weather

Unit Responsible

Surface Vessels Required

Logistical Support

Service Vessels

Nearest Airfield

Water Depth

Currents

Temperature

Task Breakdown

Time Estimate

Sign Off / Date

DIVE TECHNIQUE SELECTION

SUMMARY

AIR

OPEN CIRCUIT SCUBA

NORMAL
60 FT. 60 MIN.
MAXIMUM
130 FT. 20 MIN.

LIGHTWEIGHT GEAR

NORMAL
60 FT. 60 MIN.
MAXIMUM
90 FT. 60 MIN.

DEEP SEA GEAR

NORMAL
190 FT. 40 MIN.
MAXIMUM
250 FT. 40 MIN.

O_2

CLOSED CIRCUIT SCUBA

NORMAL
25 FT. 75 MIN.
MAXIMUM
40 FT. 10 MIN.

MIXED GAS

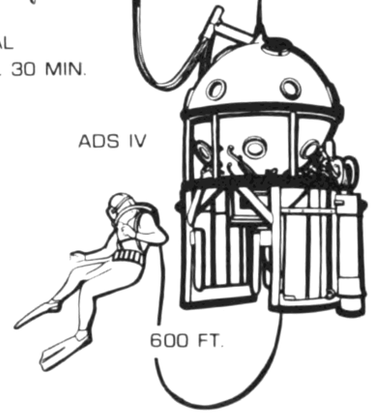
MK XI SEMI-CLOSED SCUBA

NORMAL
300 FT. 30 MIN.

MK X CLOSED CIRCUIT SCUBA

NORMAL
300 FT. 30 MIN.

ADS IV



600 FT.

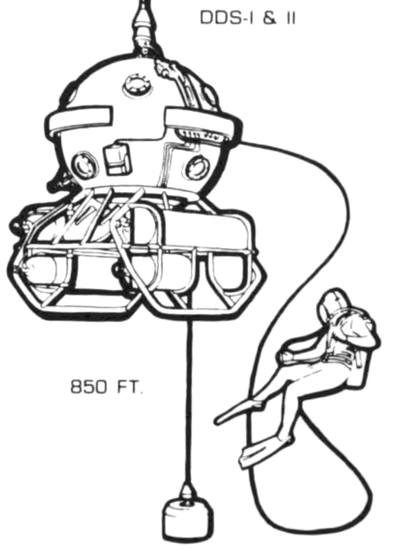
RECIRCULATING HELIUM-OXYGEN

NORMAL
300 FT. 30 MIN.

MK VI SEMI-CLOSED SCUBA

NORMAL
170 FT. 35 MIN.
MAXIMUM
180 FT. 30 MIN.

DDS-I & II



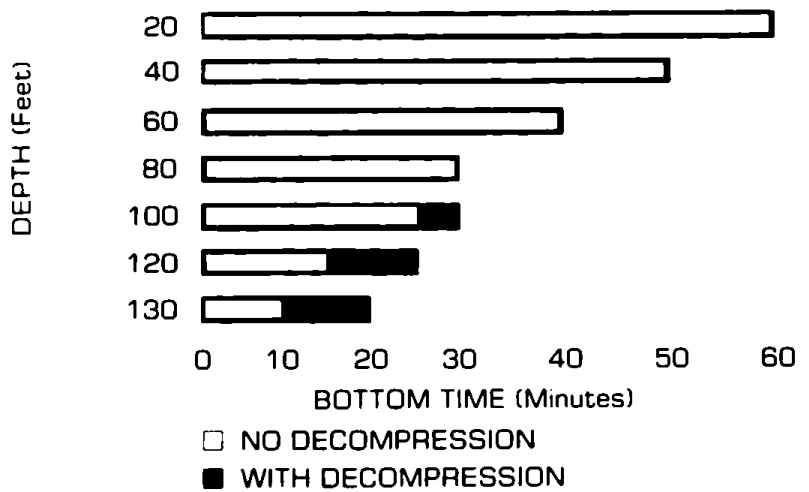
850 FT.

OPEN CIRCUIT SCUBA—AIR

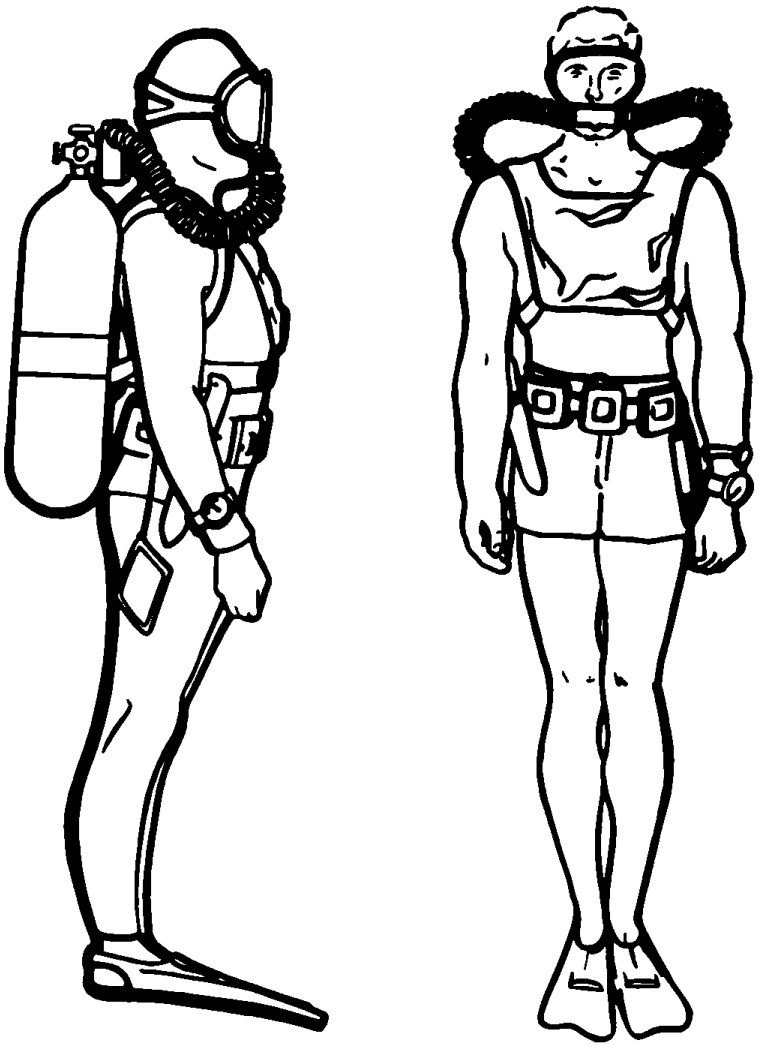
(Twin 90 ft.³ Tanks / 500 PSI Reserve – One Tank / Average Swimming)

DEPTH/DURATION LIMITS

RECOMMENDED – 60 Feet/60 Minutes
MAXIMUM[1] – 130 Feet/20 Minutes



CURRENT	1 Knot Maximum
WATER TEMPERATURE	Above 68°F: No protection required Below 68°F: Wet suit required
TYPE OF WORK	Light; Medium to heavy for EOD, UDT or SEAL operations
BOTTOM CONDITIONS	Hard, clean bottom; avoid use in areas of coral and jagged rock to prevent injury
VISIBILITY	Moderate to good, no minimum for EOD/UDT/SEAL operations.



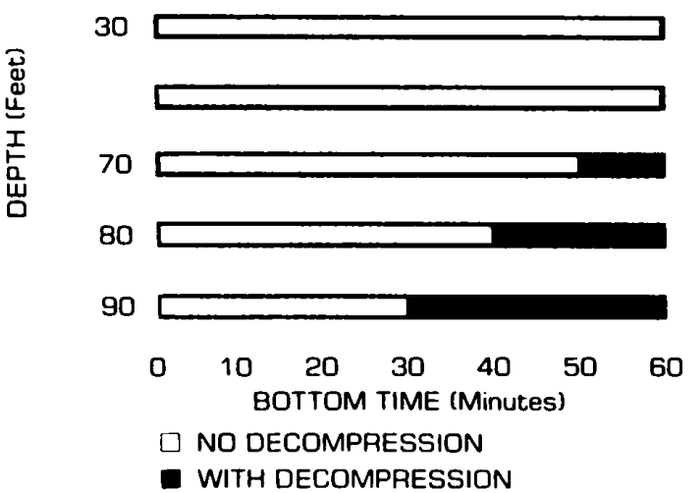
Note:
1. Greater depths not requiring decompression may be authorized by a diving officer.

LIGHTWEIGHT GEAR—AIR

DEPTH/DURATION LIMITS

RECOMMENDED—60 Feet/60 Minutes

MAXIMUM—90 Feet/60 Minutes

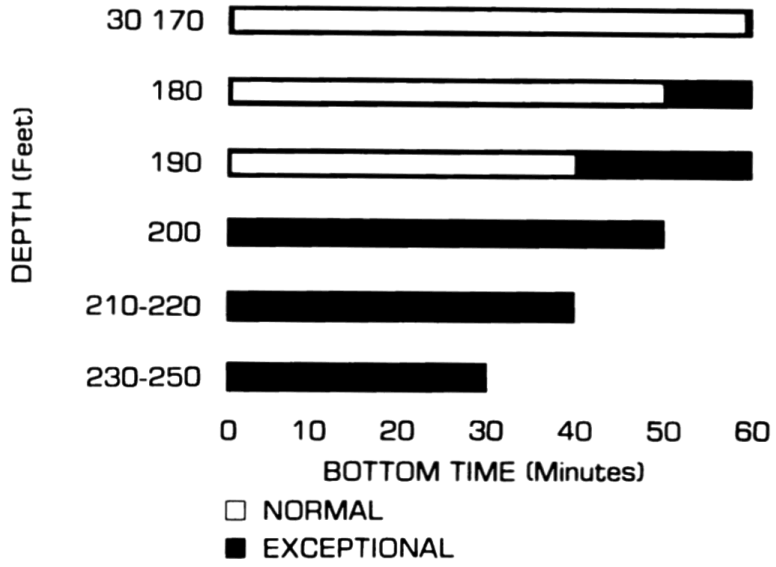


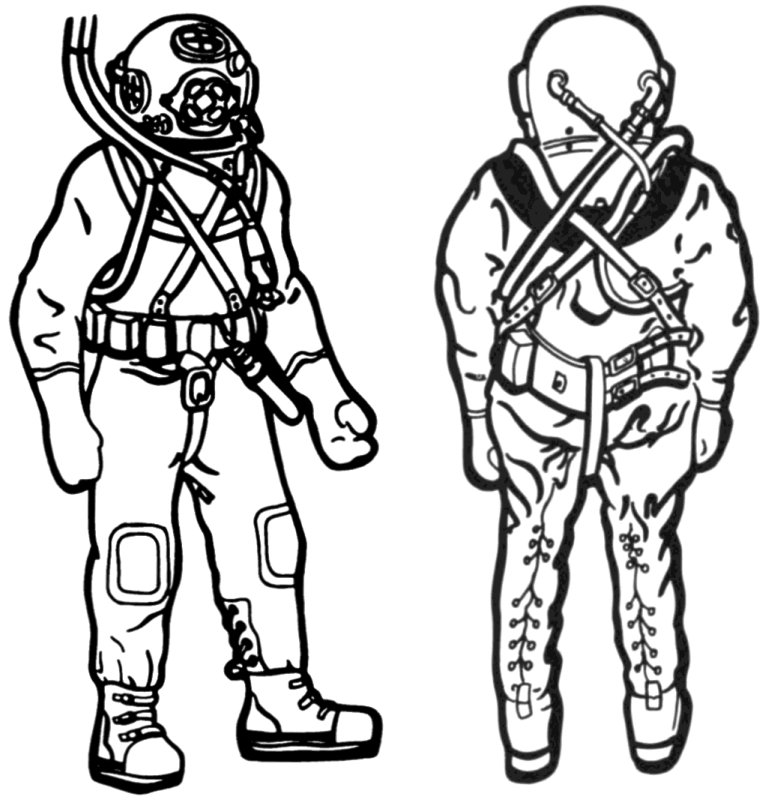
CURRENT	2.5 knots maximum
WATER TEMPERATURE	Above 60°F: Suit only Below 60°F: Suit and underwear
TYPE OF WORK	Heavy Search and recovery, construction, major repairs
BOTTOM CONDITIONS	All types of bottoms, including mud and soft sediment; avoid coral and jagged rocks unless adequately protected with coveralls
VISIBILITY	No minimum

DEEP SEA GEAR—AIR

DEPTH/DURATION LIMITS

RECOMMENDED[1] – 190 Feet/40 Minutes
MAXIMUM[1] – 250 Feet/40 Minutes





CURRENTS	2.5 knots maximum
WATER TEMPERATURE	Above 60°F: Suit, underwear Below 60°F: Suit, extra underwear
TYPE OF WORK	Heavy Search and recovery, construction, major repairs
BOTTOM CONDITIONS	All types of bottoms, including mud and soft sediment; avoid coral and jagged rocks unless adequately protected with coveralls
VISIBILITY	No minimum

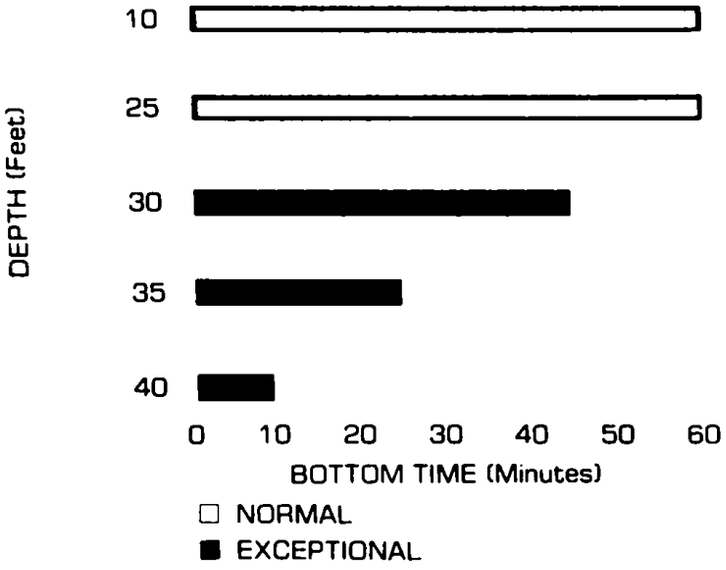
NOTE:

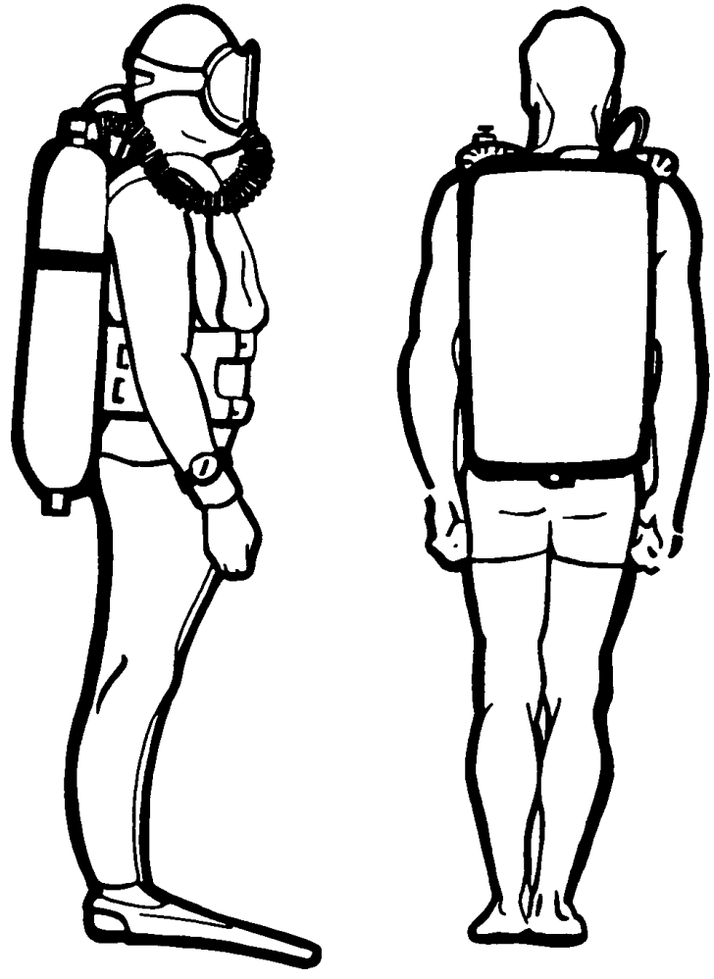
1. Air diving below 170 feet requires a qualified medical officer **and** a recompression chamber on scene.

OXYGEN RECIRCULATOR—100% OXYGEN

DEPTH/DURATION LIMITS

RECOMMENDED—25 Feet/75 Minutes
MAXIMUM—40 Feet/10 Minutes



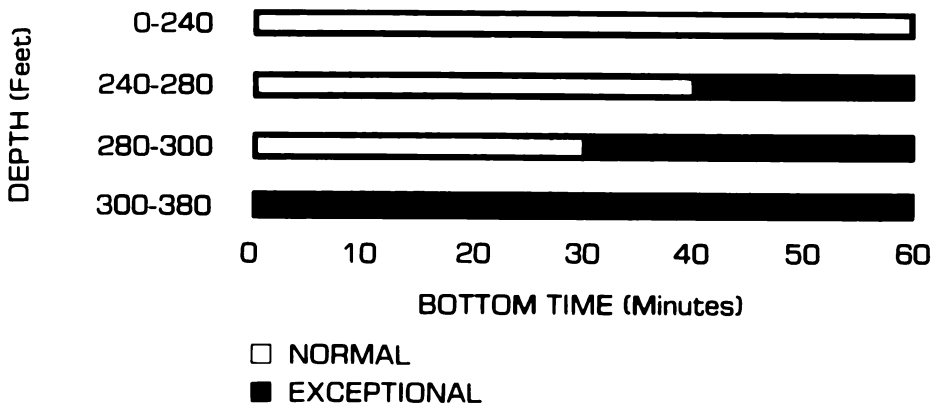


CURRENTS	1 knot maximum
WATER TEMPERATURE	Above 68°F: No protection required Below 68°F: Wet suit
TYPE OF WORK	Light to medium Search and inspection, demolition, clandestine operations
BOTTOM CONDITIONS	Hard, clean bottom; avoid use in areas of coral and jagged rock to prevent injury
VISIBILITY	Moderate to good, no minimum for EOD/UDT/SEAL operations.

DEEP SEA HELIUM-OXYGEN RECIRCULATING—MIXED GAS

DEPTH/DURATION LIMITS

RECOMMENDED[2] – 300 Feet/30 Minutes
MAXIMUM[1] – (None Specified)



CURRENTS	2.5 knots maximum
WATER TEMPERATURE	Above 60°F: Suit, underwear Below 60°F: Suit, extra underwear
TYPE OF WORK	Heavy Search and recovery, construction, major repairs
BOTTOM CONDITIONS	All types of bottoms, including mud and soft sediment; avoid coral and jagged rocks unless adequately protected with coveralls
VISIBILITY	No minimum

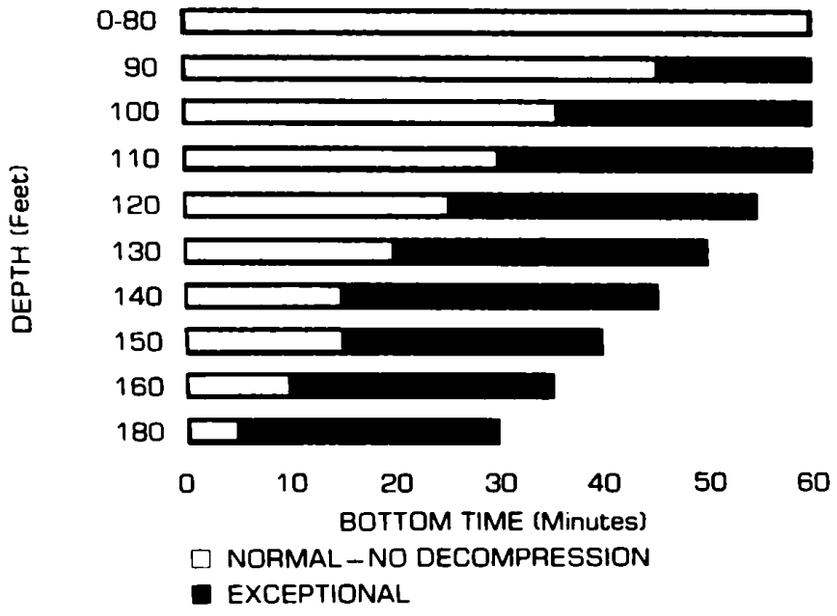
NOTES:

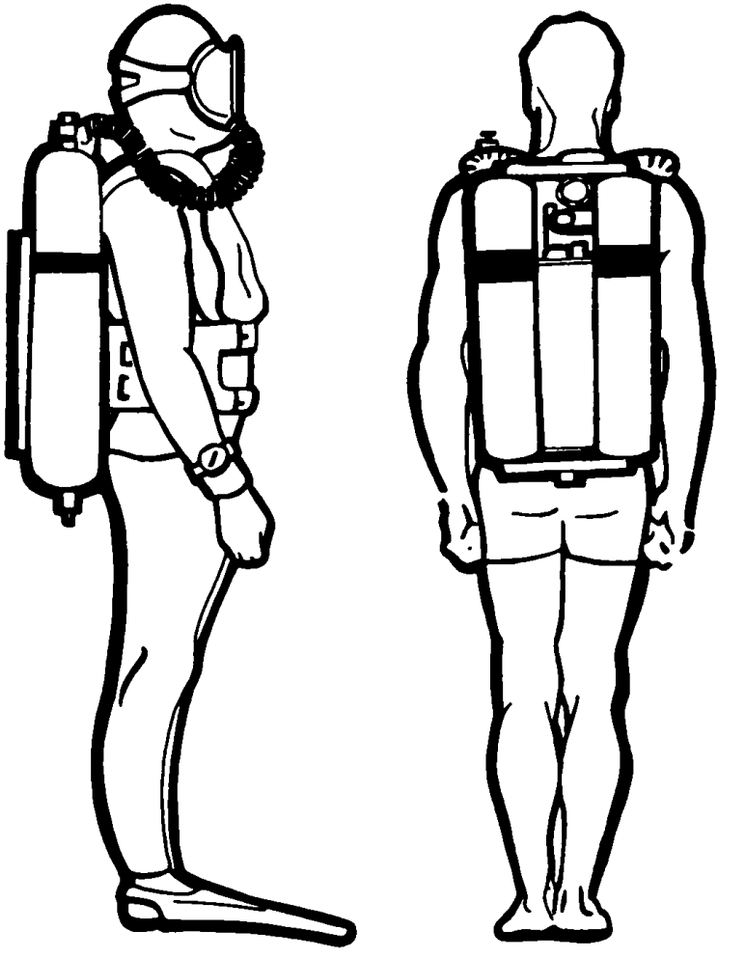
1. 300-foot limit is not to be exceeded without the direct authorization of the CNO in accordance with OPNAV 9940.1E.
2. When conducting helium-oxygen diving, a qualified medical officer and a recompression chamber must be on location. This requirement may be waived by EOD, UDT, or SEAL diving officer during actual diving operations.

SEMI-CLOSED CIRCUIT SCUBA MK VI—MIXED GAS

DEPTH/DURATION LIMITS

RECOMMENDED[1] – 170 Feet/35 Minutes
MAXIMUM – 180 Feet/30 Minutes





CURRENTS	1 knot maximum
WATER TEMPERATURE	Above 68°F: No protection Below 68°F: Wet Suit Below 45°F: Heated Suit
TYPE OF WORK	Light; Medium to heavy for EOD, UDT or SEAL operations
BOTTOM CONDITIONS	Hard, clean bottom; avoid use in areas of coral and jagged rock to prevent injury
VISIBILITY	Moderate to good, no minimum for EOD/UDT/SEAL operations

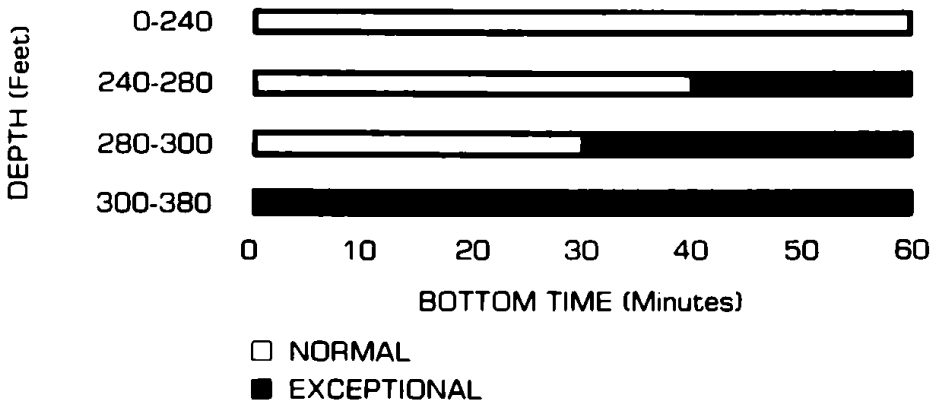
NOTE:

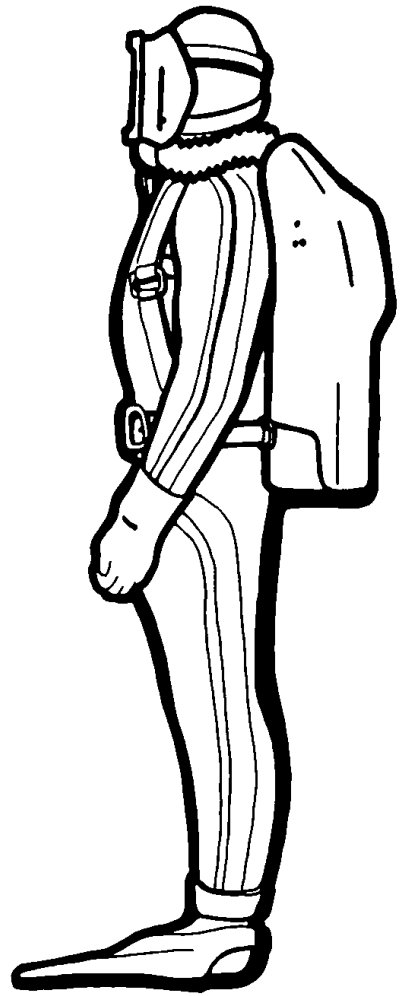
1 When conducting helium oxygen diving, a qualified medical officer and a recompression chamber must be on location. This requirement may be waived by EOD, UDT, or SEAL diving officer during actual diving operations.

CLOSED CIRCUIT SCUBA MK X MOD 3—MIXED GAS

DEPTH/DURATION LIMITS

RECOMMENDED[2] – 300 Feet/30 Minutes
MAXIMUM[1] – (None Specified)





CURRENTS	1 knot maximum
WATER TEMPERATURE	Above 68°F: No protection Below 68°F: Wet Suit Below 45°F: Heated Suit
TYPE OF WORK	Medium Search and inspection, demolition, clandestine operations
BOTTOM CONDITIONS	Hard, clean bottom; avoid use in areas of coral and jagged rock to prevent injury
VISIBILITY	Moderate to good, no minimum for EOD/UDT/SEAL operations.

NOTES:

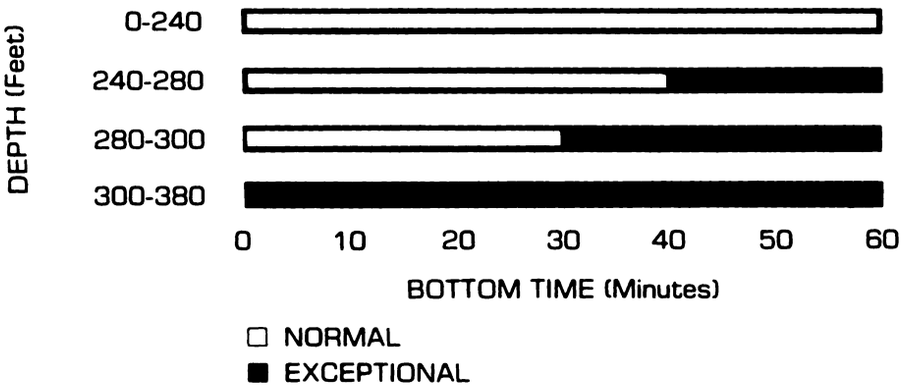
1. 300-foot limit is not to be exceeded without the direct authorization of the CNO in accordance with OPNAV 9940.1E.
2. When conducting helium oxygen diving, a qualified medical officer and a recompression chamber must be on location. This requirement may be waived by EOD, UDT, or SEAL diving officer during actual diving operations.

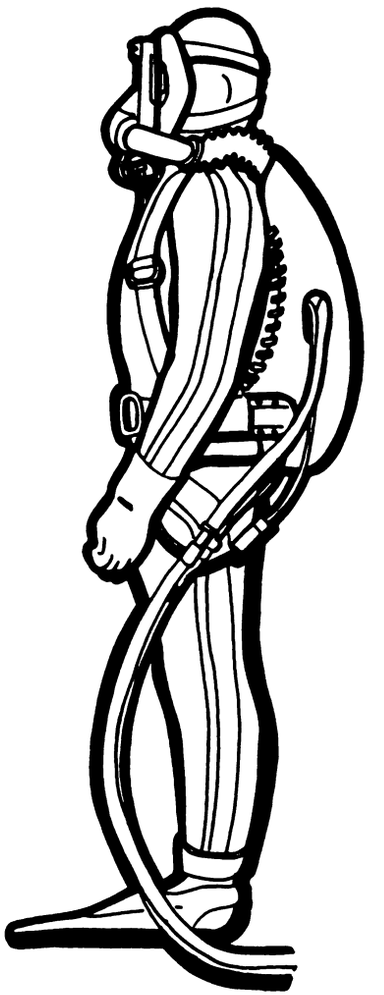
SEMI-CLOSED CIRCUIT SCUBA MK XI MOD 0—MIXED GAS

(Tethered Only)[3]

DEPTH/DURATION LIMITS

RECOMMENDED[2]—300 Feet/30 Minutes
MAXIMUM[1]—(None Specified)





CURRENTS	1 knot maximum
WATER TEMPERATURE	Above 68°F: No protection Below 68°F: Wet Suit Below 45°F: Heated Suit
TYPE OF WORK	Medium Search and inspection, demolition
BOTTOM CONDITIONS	Hard, clean bottom; avoid use in areas of coral and jagged rock to prevent injury
VISIBILITY	No minimum

NOTES:

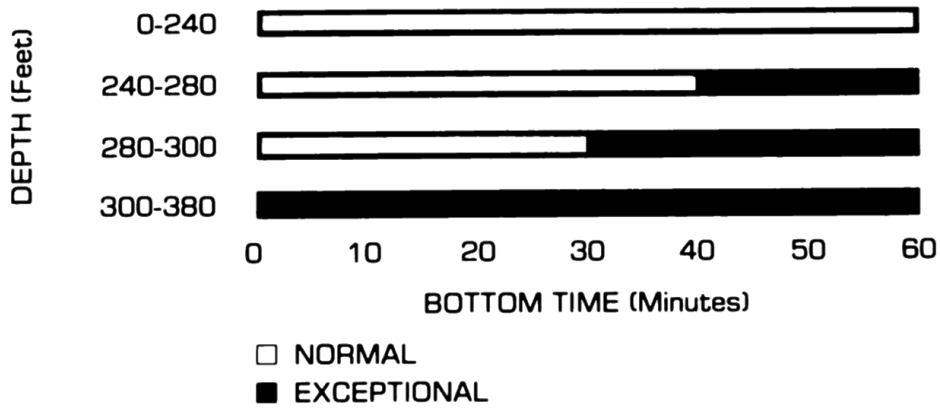
1. 300-foot limit is not to be exceeded without the direct authorization of the CNO in accordance with OPNAV 9940.1E.
2. When conducting helium oxygen diving, a qualified medical officer and a recompression chamber must be on location. This requirement may be waived by EOD, UDT, or SEAL diving officer during actual diving operations.
3. Recommended that the MARK XI use be restricted to tethered applications from Deep Diving Systems and bottom habitats.

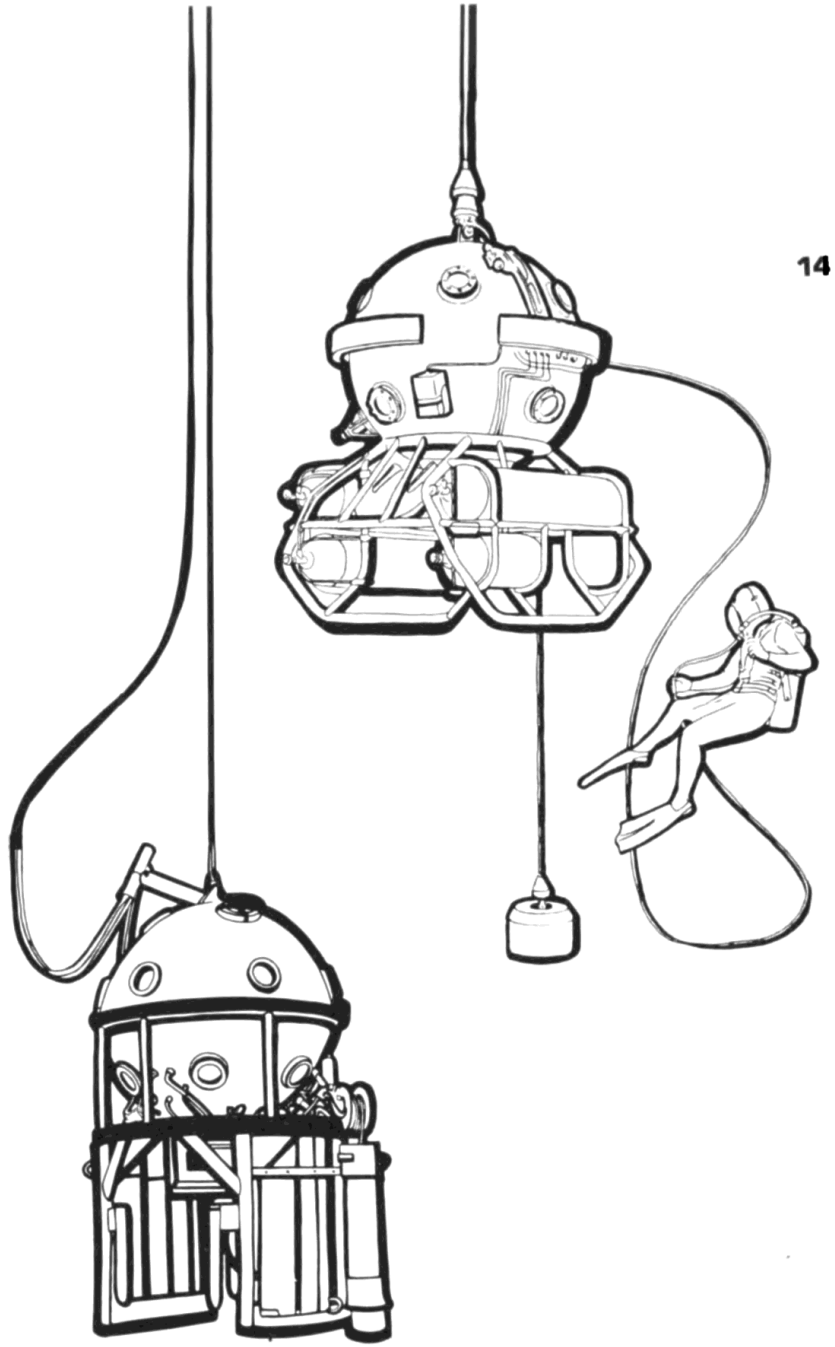
DEEP DIVING SYSTEMS—MIXED GAS

DEPTH/DURATION LIMITS

RECOMMENDED – Internal Pressure
300 Feet/30 Minutes

MAXIMUM[1] ADS-IV 600 Feet
DDS-I 850 Feet





CURRENTS	2.5 knots maximum
WATER TEMPERATURE	28°F
TYPE OF WORK	Medium Search, inspection, minor repairs
BOTTOM CONDITIONS	Avoid deploying PTC in areas of hard objects when subjected to strong currents to prevent structural damage to hull and view ports
VISIBILITY	No minimum

NOTE:
1. 300-foot limit is not to be exceeded without the direct authorization of the CNO in accordance with OPNAV 9940.1E.

RECOMMENDED MANNING LEVELS FOR VARIOUS TYPES OF DIVING

SCUBA

	SURFACE CREW OPTIMUM		MINIMUM	
DESIGNATION	ONE DIVER	TWO DIVERS	ONE DIVER	TWO DIVERS (D)
DIVING SUPERVISOR (C)	1	1	1	1
DIVER	1	2	1	2
STANDBY DIVER	1	1	1	1
TENDER	1	2 (A)	1 (A-B)	2 (A-B)
TIMEKEEPER / RECORDER	1	1		
TOTAL MEN REQUIRED	5	7	4	6

SURFACE SUPPLIED AIR

	LIGHTWEIGHT GEAR		DEEP SEA GEAR		BELOW 170 FEET	
DESIGNATION	ONE DIVER	TWO DIVERS	ONE DIVER	TWO DIVERS	ONE DIVER	TWO DIVERS
DIVING OFFICER				1	1	1
DIVING MEDICAL OFFICER (REQUIRED)					1	1
DIVING SUPERVISOR	1	1	1	1	1	1
DIVER	1	2	1	2	1	2
STANDBY DIVER	1	1	1	1	1	1
TENDER	2 (B)	3	2	3	3	4
TIMEKEEPER / RECORDER		1	1	1	1	1
TOTAL MEN REQUIRED	5	8	6	9	9	11

	SURFACE SUPPLIED MIXED GAS		DEEP DIVING SYSTEM (E)	
DESIGNATION	ONE DIVER	TWO DIVERS	ADS IV	DDS -1-
DIVING OFFICER	1	1	1	1
DIVING MEDICAL OFFICER (REQUIRED)	1	1	1	1
DIVING SUPERVISOR	1	1	1	1
DIVER	1	2	2	2
STANDBY DIVER	1	1	2	2
TENDER	3	4		
TIMEKEEPER / RECORDER	1	1	1	1
RACK OPERATOR	1	1		
CONTROL VAN OPERATOR			1	1
WINCH / TUGGER OPERATOR			1	2
HOSE / CABLE HANDLER			1	2
EXTRA MEN				3
TOTAL MEN REQUIRED	10	12	11	16

NOTE:

A. One Tender/Diver required when Divers are surface tended. If using Buddy System one Tender required for each Buddy pair.
B. Tender also acts as Timekeeper.
C. EOD Diving Officer required on scene for all EOD operations.
D. Four-man EOD team authorized to use two Divers.
E. Assistance in handling PTC (SDC) required from ship's crew, this manpower not shown. Levels for non-saturation diving only.

PERSONNEL REQUIREMENTS—GENERAL GUIDELINES

DESIGNATION OF PERSONNEL	QUALIFICATIONS	RESPONSIBILITIES
Diving Officer	Commissioned Officer, preferably qualified as: Diving Officer (general)–9312 Deep Sea (HeO_2) Diving Officer–9313 Ship Salvage Diving Officer–9314 Ship Salvage Operations Officer–9375 EOD Diving Officer–9230	Complete authority and responsibility in the conduct of diving operations until properly relieved.
Diving Medical Officer	Medical Officer qualified as: Submarine Medical Officer–0090	Responsible for the medical care and treatment of divers.
Diving Supervisor	Diving Officer or his specified representative: Diving Officer–See above Master Diver–5341/5340 Diver First Class–5342/5311 Diver Second Class–5343 Diver EOD–5332	Complete authority and responsibility in the conduct of operations. Plan the operation. Brief the divers. Take all proper precautions against foreseeable contingencies. Supervise and direct diving operation. Maintain post on surface, except 1. Emergency situations 2. Predive and postdive inspections 3. Give directions
Diver	Diver qualified for depth of operation and diving technique: Master Diver–5341/5340 Diver First Class–5342/5311 Diver Second Class–5343 SCUBA Diver–5345 (SCUBA operations only) Diver EOD–5332	Carry out underwater task to the best of his ability. Obey a signal to surface. Understand the briefing completely.

Standby Diver	Diver qualified for depth of operation and diving technique: See Diver designations above.	Be prepared to enter water immediately and render assistance to diver in emergency situations.
Tender	Qualified Diver: Diver First Class – 5342/5311 Diver Second Class – 5343 SCUBA Diver – 5345 (SCUBA Operations only) Diver EOD – 5332	Insure that the diver receives proper care while topside and submerged. Dress diver and check proper functioning of diver's equipment before descent. Maintain frequent communications with diver. Tend divers hoses and lines, prevent slack. Be aware of diver's location on the bottom. Insure adequate flow of air to diver. Be aware of diver's depth at all times. Advise diver and supervisor when bottom time is about to expire. Be alert for emergencies.
Timekeeper/Recorder	Qualified Diver: Diver First Class – 5342/5311 Diver Second Class – 5343 SCUBA Diver – 5345 (SCUBA operations only) Diver EOD – 5332	Maintain careful record in Diving Log of: 1. Descent time. 2. Time of exposure on bottom. 3. Depth of dive. 4. Time of ascent to first stop. 5. Time of all decompression stops. Maintain copy of USN Standard Decompression Tables. Be prepared to advise supervisor or tender of proper decompression schedule to be used. Advise supervisor and tender when preplanned bottom time is about to expire. Know the probable duration of the apparatus. Know the probable diving depth. Maintain voice communications with diver and visual awareness of diver's depth via the pneumofathometer.

DESIGNATION OF PERSONNEL	QUALIFICATIONS	RESPONSIBILITIES
Rack Operator	Qualified Diver: Diver First Class – 5342/5311 Diver EOD – 5332	Insure adequate supply of gas to diver. Maintain correct gas supply over-pressure for depth and apparatus. Switch gas mixes at proper depth. Record gas consumption data before and after dive. Be cognizant of oxygen percentages and readiness of standby bank.
Diving Medical Corpsman	Hospital Corpsman qualified as: Medical Deep Sea Diving Technician – 8493/5342 8493/5311 **Special Note** – Diving Medical Corpsmen are qualified as Diver First Class and they are also employed in this capacity in diving operations.	Insure the physical fitness of divers prior to diving operations. Prescribe recompression treatment in cases of decompression sickness unless there is a qualified Medical Officer in attendance. Provide medical aid inside recompression chamber.
Control Van Operator	Diver qualified by special training in the operation of the Deep Diving System being used: Master Diver – 5341/5340 Diver First Class – 5342/5311 Diver Second Class – 5343	Maintain proper atmosphere and pressure in deck decompression chamber. Decompress divers according to established schedule. Maintain communications with divers. Perform predive checkout of all systems between control van, personnel transfer capsule and deck decompression chamber. Be alert for emergencies. Advise diving supervisor of status of divers at frequent intervals.

Winch/Tugger Operator	Diver qualified by special training in the operation of the Deep Diving System being used: Master Diver – 5341/5340 Diver First Class – 5342/5311 Diver Second Class – 5343	Deploy, retrieve, and mate Personnel Transfer Capsule (PTC). Operate umbilical or lift wire winch during launch and retrieval of PTC. Operate or supervise operation of PTC tugger line winches. Supervise and coordinate deck crane handling of PTC. Inspect all elements of PTC handling system prior to deployment. Supervise handling and storage of umbilical hose or strength-power-communication cable.
Hose/Cable Handler	Diver qualified by special training in the operation of the Deep Diving System being used: Master Diver – 5341/5340 Diver First Class – 5342/5311 Diver Second Class – 5343	Maintain the free flow of umbilical hose or strength-power-communications cable (SPCC) during deployment and retrieval of PTC. Attach and detach umbilical bundle to lift wire for PTC operations. Maintain surveillance of condition of umbilical or SPCC during launch and retrieval operations and report potential defect.
Extra Man	Diver qualified by special training in the operation of the Deep Diving System being used: Master Diver – 5341/5340 Diver First Class – 5342/5311 Diver Second Class – 5343	Have knowledge of all positions in which he will be assisting. Be prepared to assume responsibility of personnel he is relieving. Insure that all instructions have been obtained from person being relieved prior to assuming position.

PHYSICAL CONDITION OF DIVING PERSONNEL

The capability of diving equipment is limited by the capability of the man using the equipment, and the capability of the man is limited by his physical condition. To insure the safety of the individual diver and his associates, a diving supervisor, with the aid of the medical officer and corpsman, should check the physical condition of diving personnel before and during any diving operation.

All diving personnel are required to currently meet the physical qualifications of Chapter 15, Article 30, of the Manual of the Medical Department.

Encourage personnel to report any symptom or condition which might interfere with or prevent them from diving.

If a diver seriously desires not to make a certain dive he should not be penalized or ridiculed. Psychological adjustment to diving and other specific duties should be assessed.

A DIVING SUPERVISOR MUST—

A. Determine that the Diver feels fit

B. Prohibit Diving For

Any degree of alcoholic intoxication or hangover
Respiratory or middle-ear disease
Skin or external-ear infections
Excessive fatigue
Current emotional distress

NOTES

NUMBER OF DIVING TEAMS REQUIRED FOR OPERATION

DEPTH= _____

DIVING TECHNIQUE= _____

A ESTIMATED BOTTOM TIME REQUIRED FOR OPERATION= _____

B PLANNED BOTTOM TIME PER DIVE= _____

C TOTAL TIME OF DIVE (FROM ESTIMATOR, reverse side)= _____

D PLANNED NUMBER OF DIVES PER DAY= _____

E ESTIMATED NUMBER OF DIVES REQUIRED FOR OPERATION

E _____ $= \frac{A}{B} =$ _____ ÷ _____

F TOTAL OPERATIONAL DIVING TIME

F _____ = E x C = _____ x _____

G OPERATIONAL DIVING TIME PER DAY

G _____ = D x C = _____ x _____

TOTAL OPERATIONAL DIVING DAYS

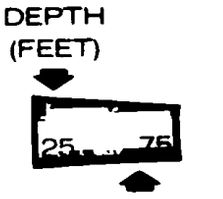
H _____ $= \frac{F}{G} =$ _____

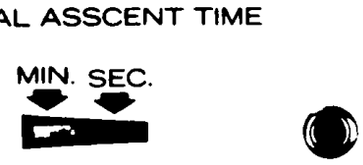
PLANNED DIVES PER DAY PER TEAM _____

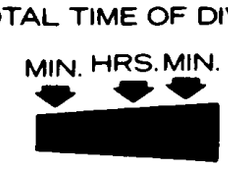
NUMBER OF DIVING TEAMS REQUIRED

J _____ $= \frac{D}{T} =$ _____

TOTAL DIVING TIME ESTIMATOR



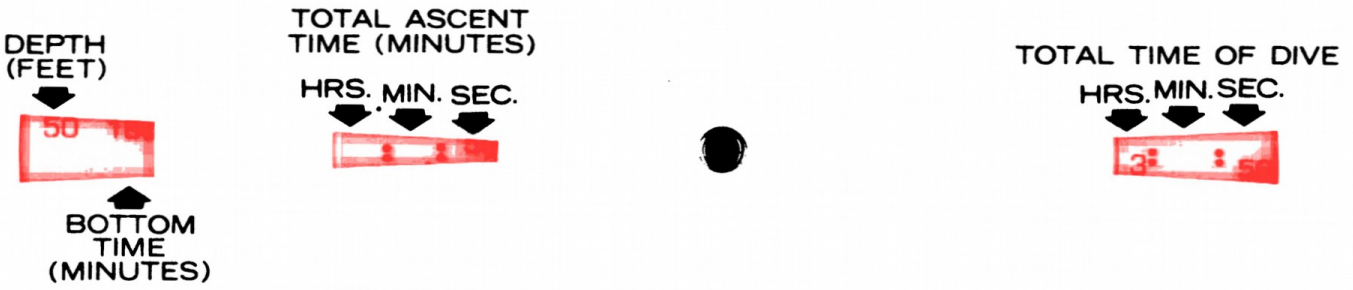




LEGEND

AIR
OXYGEN

TOTAL DIVING TIME
. ESTIMATOR



LEGEND

HELIUM-OXYGEN (SCUBA)
HELIUM-OXYGEN (DEEP SEA)
SATURATION

OPERATION TIMETABLE

Operational Start Date _____

	ESTIMATED TIME (DAYS)	COMPLETION DATE	REMARKS
MOBILIZATION TIME			
Equipment & Supply Logistics			
Equipment Installation & Checkout			
Personnel Mobilization			
Ship Transit Time			
Ship Mooring			
OPERATIONAL TIME			
Search Time			
Diving Time			
Special Operations Time			
WEATHER CONTINGENCY			
DEMOBILIZATION TIME			
Ship Transit Time			
Equipment Maintenance & Removal			
GENERAL CONTINGENCY			
TOTAL OPERATION TIME			

DIVE REPORTING

REQUIREMENTS

OPNAV Form 9940/1 must be filed for every dive (or hyperbaric exposure incident to diving) conducted under the auspices of the U.S. Navy in accordance with OPNAVINST 9940.2. Lines 1 through 5 of the form must be filled out for every dive. Line 6 must be completed for each dive resulting in accidents or injuries.

FORM TYPE

The Diving Log–Accident/Injury Report (OPNAV Form 9940/1) is a coded computer sheet which is inserted into a multi-leaf overlay (OPNAV Form 9940/1A). Instructions for writing the correct code numbers and letters on the report are printed on the leaves of the overlay.

OTHER FORMS

OPNAV 9940/1 replaces Diving Log Sheet (NAVSHIPS Form 9940/1) and Report of Decompression Sickness and All Diving Accidents (NAVMED Form 6420/1). This form is used in lieu of the Accidental Injury/Death Report (OPNAV Form 5100/1) except in cases where a JAG Report is required. In this situation both forms OPNAV 9940/1 and OPNAV 5100/1 must be filed.

SEND COMPLETED FORMS TO
Naval Safety Center, Norfolk, Virginia within 10 days.

INSTRUCTIONS FOR PREPARATION OF OPNAV 9940/1

1. Each of the individual overlays contains instructions and coding symbols for each of the blocks on one line of the report form.
2. The following explanatory notes pertain to specific entry requirements:
   A. Activity dive set/group number; the sequential number of the particular dive, participated in by one or more divers, conducted by the reporting activity on that calendar date; i.e., 08 would mean the eighth dive conducted by the activity on the reported date, not by the eighth diver.
   B. Total number of divers in the group; numerical total from 01 to 99 divers participating in a particular activity dive.
   C. The diver's number within the group; each diver in a group of divers participating in a particular activity dive is to be assigned a two-digit number from 01 to 99. The highest diver number must equal the total number of divers in the group, i.e., if 10 divers are participating in a dive, they will be numbered 01 through 10.
3. For each dive (subparagraph 2A above) in which no accident occurs, one report form with lines 1-5 (through decompression profile) is to be completed. Lines 1 and 2 of this report form will contain the data for diver number one of the group (defined in subparagraph 2C above). A separate report form containing lines 1 and 2 data only is to be completed for each of the other divers participating in the dive.
4. In the event any item in lines 4 or 5 for a particular diver is different from the group, that item will be filled in on the report form for the particular diver.
5. In the event of a diving or diving related accident or injury, the entire report form (Lines 1-6) is to be completed for each affected diver.
6. Space at the top of each report form is provided for narrative remarks. In most cases, remarks will not be required; however, commands are encouraged to submit additional clarifying information, comments, or observations. A narrative is required in the event of accident or injury.

REPETITIVE DIVE WORKSHEET

I. PREVIOUS DIVE

_____MINUTES
_____FEET

See TABLE 1-10 or 1-11 for Repetitive Group Designation

Group _____

II. SURFACE INTERVAL

_____HOURS _____MINUTES on Surface
GROUP _____from I.

See TABLE 1-12 for New Group

Group _____

III. RESIDUAL NITROGEN TIME

_____ FEET (Depth of Rept. Dive)
GROUP_____from II.

See TABLE 1-13

_____Minutes

IV. EQUIVALENT SINGLE DIVE TIME

_____MINUTES (Residual Nitrogen Time from III)
+ _____MINUTES (Actual Bottom Time of Repetitive Dive)
= _____MINUTES

V. DECOMPRESSION FOR REPETITIVE DIVE

_____MINUTES (Equivalent Single Dive Time from IV)
_____FEET (Depth of Repetitive Dive)

See TABLE 1-10 or 1-11

_____NO DECOMPRESSION REQUIRED
_____DECOMPRESSION STOPS REQUIRED

_____FEET _____MINUTES
_____FEET _____MINUTES
_____FEET _____MINUTES
_____FEET _____MINUTES
_____FEET _____MINUTES

Special Notes

SECTION 2—AIR DIVING OPERATIONS

INTRODUCTION

Section 2 covers the principal instructions for conducting safe air diving operations. Before a dive is started, fill in the Operating Personnel chart and ensure that all members of the team are aware of their job and the position of the other members of the team.

The General Safety Rules should be known, understood and remembered by all team members.

The Equipment Installation, Checkout and Use section is divided up into parts covering each air diving technique. Follow the specific instructions for the equipment being used. Do not skip items in the checkout procedure and do not alter equipment or use it beyond its specified limits. Ensure that divers are completely familiar with normal and emergency modes of equipment operation before the dive is started.

The Diver Underwater Procedures section covers time-proven diver underwater techniques. Do not shortcut; use standard procedures.

USE PROPER EQUIPMENT, QUALIFIED PERSONNEL, CORRECT PROCEDURES

OPERATING PERSONNEL

Date _____

DESIGNATION	Team No. 1	Team No. 2	Team No. 3
Diving Officer			
Diving Medical Officer			
Diving Supervisor			
Diver No. 1			
Diver No. 2			
Standby Diver			
Tender No. 1			
Tender No. 2			
Tender No. 3			
Timekeeper/Recorder			
Rack Operator			
Control Van Operator			
Winch/Tugger Operator			
Hose/Cable Handler			
Extra Man			
Diving Medical Corpsman			

NOTE:
If only one Team is to be used and diver positions are to be rotated among Team Members on subsequent dives,use Team No. 2 and No. 3 slots to specify alternate positions of team members.

SAFETY RULES FOR AIR AND OXYGEN DIVING

ALWAYS

1. Check that all diving equipment is in first-class operating condition.
2. Check that all topside support equipment is in good order—air compressor, recompression chamber, etc.
3. Check that adequate support personnel are on station and properly trained for their duty—buddy diver, standby diver, tender, chamber operators, etc.
4. Check that ship is properly moored before sending diver over. Never shift a moor while a diver is down.
5. Purge hoses thoroughly if changing gas mixture between dives or during decompression.
6. Before inspecting or conducting repairs on a vessel, ensure that propellor shaft, diving planes and rudder are blocked, and sea suctions and dump lines are secured.
7. Post a watch for ship traffic in the area when a diver is below.
8. Strictly observe the decompression tables, with due consideration of modifying factors.
9. Report all signs or symptoms of physical discomfort following a dive to the Dive Supervisor.
10. Exhale continuously while making an ascent from a dive in which the air supply failed.
11. Treat by recompression if decompression sickness is suspected.

NEVER

1. Dive a man who is not a qualified diver, except for training dives.
2. Exceed a depth to which a man is qualified, both physically and technically.
3. Dive a man who is not trained in the use of the type of diving equipment he is to use.
4. Dive a man if he does not know diving hand signals.
5. Dive a man if he is not physically qualified, has passed the standard diving physical examination and is currently in good health.
6. Dive a man if he has consumed excessive alcohol in the preceeding 24 hours.
7. Start any diving operation without the presence of a qualified Diving Supervisor.
8. Start any diving operation unless everyone is briefed on the dive plan and understands his duties.
9. Start any dive without having decompression tables available. Each decompression dive profile should be preplanned with each dive. The diver should know his bottom time and decompression obligations.
10. Make a dive unless the available air supply is sufficient for all dives planned, plus an adequate reserve for a standby diver in the event of an emergency.
11. Send down a diver unless the proper diving signal is flying.
12. Set off explosives while a diver is down.
13. Hold breath during ascent from a dive in which a breathing apparatus is being used.
14. Eat before diving. Wait 1 hour after a light meal and 2 hours after a heavy meal.

DEEP-SEA RIG

ALWAYS –

1. Check operation of exhaust valve prior to each dive.
2. Prior to dive, check helmet security and ensure that the helmet lock is in place.
3. Prior to descent, check that air hose and lifeline are secured to breastplate.
4. Prior to descent, ensure that communications are operable.
5. Prior to descent, ensure that jockstrap is secured properly and faceplate is closed.
6. Have standby diver immediately available, completely suited up except for helmet and weighted belt.
7. Ensure that any electrical supply is completely insulated and diver has adequate suit and glove protection.
8. Check safety non-return valve for proper operation.
9. Ensure that air hose and helmet are purged.

NEVER –

1. Dive without a safety non-return valve on helmet.
2. Attempt diving operation unless compressor is operating satisfactorily, and emergency air supply is available.
3. Have diver on bottom during sudden squalls, heavy seas, strong tides, or other condition that would jeopardize mission or ship's moor.
4. Completely close the air-control valve except in emergency.
5. Allow a dressed diver to walk topside unattended.
6. Allow lifeline and hose to run free during diver descent.
7. Allow excessive hose and line slack while diver is on bottom.
8. Belay lifeline or hose to stanchion or fixed object. Tender always maintains control.

LIGHTWEIGHT DIVING

ALWAYS –

1. Use only equipment belts or straps with quick release feature.
2. Ensure that mask has an operable non-return valve before descent.
3. Ensure that standby diver is present and completely suited except for mask and weighted belt.

NEVER –

1. Ditch mask while on bottom except in emergency; then exhale continuously on ascent.
2. Dive without lifeline secured around diver's waist. Line should be inside all straps.
3. Dive inside a ship or in a similar situation which allows no direct ascent unless in extreme emergency.

SELF-CONTAINED DIVING (OPEN-CIRCUIT SCUBA)

ALWAYS –

1. Use buddy or surface line in poor visibility.
2. Use quick-release methods of attaching all releasable gear.
3. Avoid overexertion.
4. Be proficient in buddy-breathing techniques.
5. Use clean air from a known source.
6. Gage the cylinder pressure immediately prior to every dive.

NEVER –

1. Dive without a buddy or a surface line.
2. Wear earplugs or non-equalizing goggles.
3. Ditch scuba itself except as last resort.
4. Charge apparatus with oxygen (open-circuit scuba).
5. Dive without an adequate air reserve mechanism or submersible cylinder pressure gage.

SELF-CONTAINED DIVING (CLOSED-CIRCUIT OXYGEN SCUBA—EMERSON RIG)

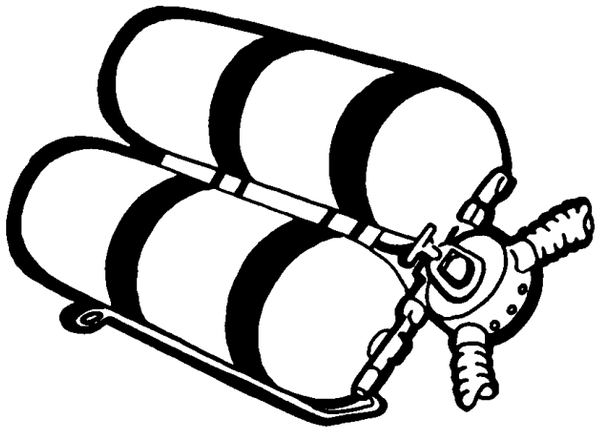
ALWAYS –

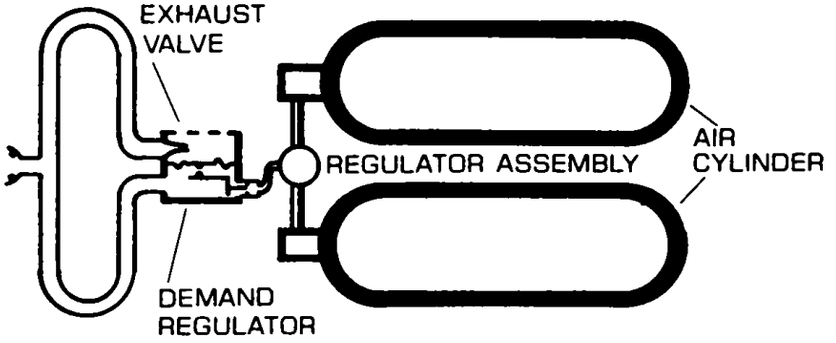
1. Use fresh absorbent in the canister.
2. Purge air from lungs and breathing system before starting dive on oxygen.

NEVER –

1. Exceed time-depth limits for pure oxygen.
2. Use oil on any of the oxygen fittings or components.
3. Charge the apparatus with any gas except oxygen (mixed-gas-closed-circuit systems excluded).

OPEN CIRCUIT SELF CONTAINED UNDERWATER BREATHING APPARATUS

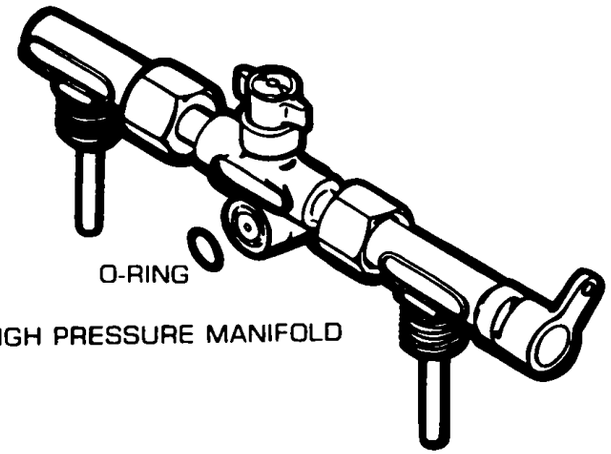




PREDIVE PROCEDURES

(To be conducted by the diver immediately before the dive)

1. ☐ Gage all cylinders.
2. ☐ Inspect cylinder charging connection O-ring; replace if damaged.



3. ☐ Attach regulator to air supply; open air cylinder valve and check for leaks. Check purge button if single hose regulator.
4. ☐ Check regulator function; take several slow breaths on the mouthpiece or in mask.
5. ☐ Close cylinder valve; turn clockwise until snug.
6. ☐ Close air reserve; push up on pull rod until it stops.
7. ☐ Check hoses and fittings; moderately pull hoses to insure tight connection to regulator and mouthpiece.

ACCESSORY EQUIPMENT

8. ☐ Check all accessory equipment to be used on dive.

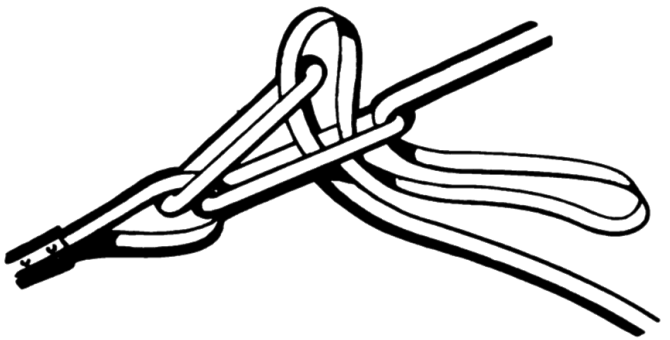
MINIMUM EQUIPMENT

- ☐ Open Circuit SCUBA
- ☐ Mark III Yoke-type Life Preserver
- ☐ Belt and Knife
- ☐ Mask ☐ Swim Fins

OPTIONAL EQUIPMENT

- ☐ Depth Gage
- ☐ Watch
- ☐ Compass
- ☐ Signal Flare
- ☐ Slate
- ☐ Life Lines
- ☐ Floats
- ☐ Protective Clothing
- ☐ Nose Clip

9. ☐ Don accessory diving gear and scuba. Secure harness with quick release.



10. ☐ Open air cylinder valve.

PREDIVE INSPECTION

(To be conducted by Dive Supervisor immediately before diver enters water.)

1. ☐ Verify predive procedures.
2. ☐ Review mission and dive profile.
3. ☐ Check buddy diver.

NOTE:
If diver is to have a surface tender instead of a buddy, the tender will assist the Dive Supervisor to insure the pre-dive inspection is complete.

SURFACE CHECKOUT

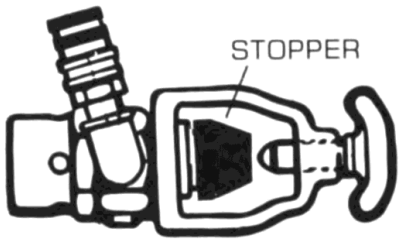
(To be conducted by both divers upon entering the water.)

1. ☐ Adjust buoyancy to slightly negative.
2. ☐ Check scuba operation.
3. ☐ Check accessory equipment.

REPORT ANY MALFUNCTION

POST DIVE PROCEDURES

1. ☐ As the diver leaves the water, the Dive Supervisor is to check him for any signs of sickness or injury that may have resulted from the dive.
2. ☐ Inspect all equipment thoroughly for damage. Report any defects noted during or after the dive. Correct all defects as soon as possible after the dive.
3. ☐ Before removing the regulator assembly from the air cylinder, close the air cylinder valve and inhale through the mouthpiece to discharge air remaining in the system.
4. ☐ Rinse all the diving gear with fresh water.
5. ☐ Stow cylinders securely. **Do not leave the regulator mounted to the cylinder.**
6. ☐ Insert a rubber stopper in the yoke of the regulator assembly to prevent water from leaking into the high pressure side of the assembly.



MAINTAIN ALL EQUIPMENT ON A REGULAR SCHEDULE TO ENSURE THAT IT IS OPERATIONAL AT ALL TIMES.

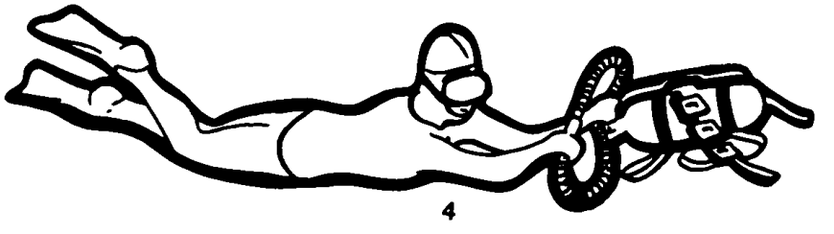
UNDERWATER PROCEDURES

DITCHING THE SCUBA

To remove the scuba underwater, first remove the weight belt and drape it across the thighs to permit sitting on the bottom (1). Unfasten the harness and crotch strap. Reach back and grasp the tank with both hands. Keeping the regulator close to the head, lift the unit over the head and hold between the legs (2). Bend forward and breathe shallowly while transferring the weight belt from the knees to the tank (3). Stretch out to be completely away from the tank, take a half-breath and place the hose between the regulator and the air valve to prevent it from floating upward (4). Ascend to the surface, **exhaling slowly** and **continuously.**

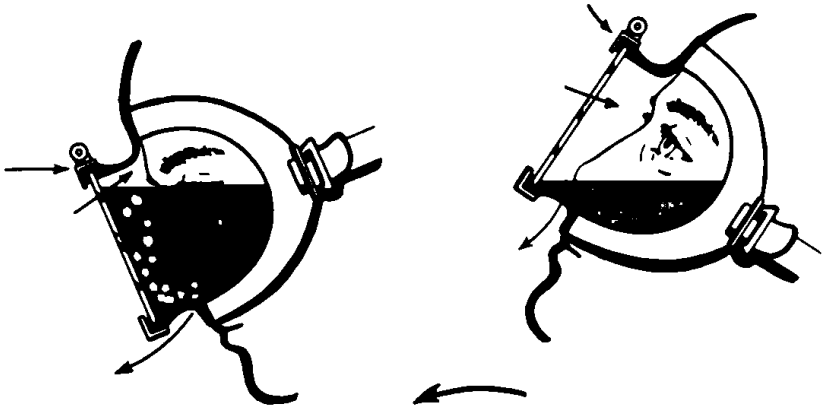
DONNING THE SCUBA

This process is just the reverse of ditching. Grasp the tank to stay on the bottom and place the mouthpiece in the mouth (4) and (3). Transfer the weight belt from the tank over to the knees. Grasp the tank near the regulator with both hands and pass it over the head, keeping the regulator close to the head (2). While sitting on the crotch strap, fasten the harness with safety hitches (1). Put on the weight belt and resume dive.



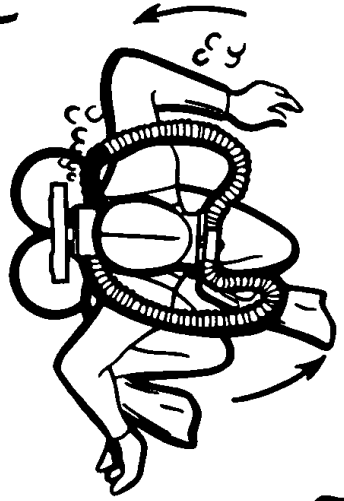
MASK CLEARING

To clear a flooded mask, gently press the upper portion of the mask toward the face. Exhale into the mask, forcing water out the bottom of the mask. As water is being forced out, gradually tilt the head backward until the mask is clear.



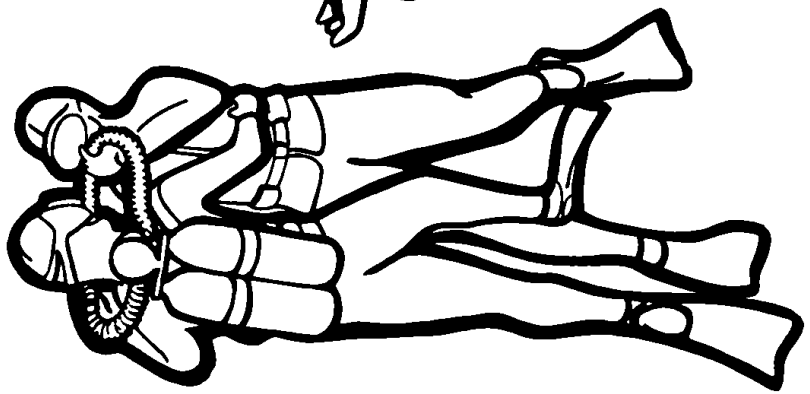
HOSE CLEARING

If the exhaust hose becomes flooded, roll to left side and exhale. Resume original position and continue normal breathing.



BUDDY BREATHING

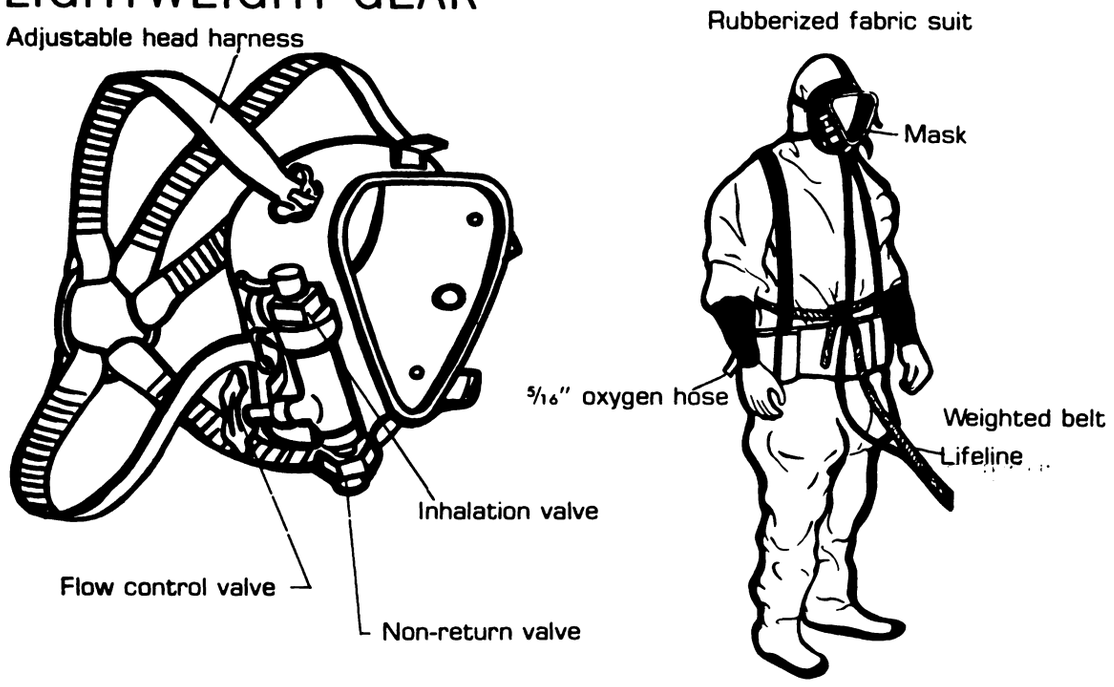
In the event that it becomes necessary for one diver to share his air supply with his buddy, the two divers face each other in either a horizontal or vertical position. After inhalation, the diver takes the mouthpiece out of his mouth and hands it to his buddy. The buddy rotates the mouthpiece, places it in his mouth and inhales. If ascending while buddy breathing, the diver without the mouthpiece must remember to exhale normally to prevent air from expanding his lungs.



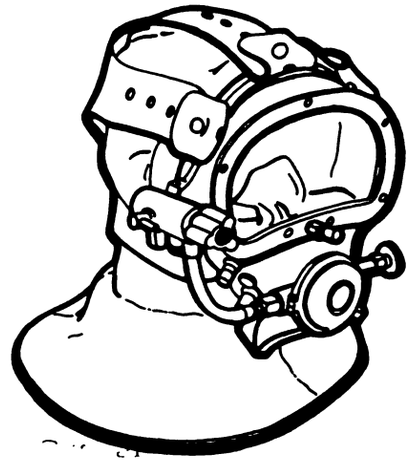
DECOMPRESSION

When possible, plan the scuba dive to eliminate the need for decompression. If decompression is necessary, surface personnel must rig the descending line, or some other surface line, with markers to identify the required decompression stop depths. If available, use a diving stage for decompression. Plan decompression without using the air reserve as a source of air.

LIGHTWEIGHT GEAR



STANDARD LIGHTWEIGHT DIVING OUTFIT



KIRBY-MORGAN B-8 BAND MASK

PREDIVE PROCEDURE

(To be conducted by the Dive Supervisor)

1. ☐ Check the primary and auxiliary air supply systems. Rig spare air hose and mask.
2. ☐ Check all air connections.
3. ☐ Check non-return valve.
4. ☐ Close flow control valve. Pressurize air supply hose. Check for leaks.
5. ☐ Take depth soundings.
6. ☐ Check descent line.
7. ☐ Check that all decompression stops are properly marked.
8. ☐ Check recompression chamber.

ACCESSORY EQUIPMENT

9. ☐ Check all accessory equipment to be used by the diver.

MINIMUM EQUIPMENT

- ☐ Diving dress
- ☐ Weighted belt
- ☐ Mask
- ☐ Air supply hose
- ☐ Life line
- ☐ Knife

OPTIONAL EQUIPMENT

- ☐ Cuffs
- ☐ Gloves
- ☐ Underwear
- ☐ Overalls
- ☐ Tool bag
- ☐ Light
- ☐ Weighted shoes
- ☐ Wet suit
- ☐ Other

INTERIM LIGHTWEIGHT OUTFIT ACCESSORY EQUIPMENT

- ☐ KMB-8 Band Mask
- ☐ Wet suit
- ☐ Weighted belt
- ☐ Swim fins or shoes
- ☐ Air supply hose
- ☐ Communication cable
- ☐ Knife

10. ☐ Dress the diver as per recommended procedures.

NOTE
Shoulder straps should be crossed in the back only and should pass under the metal clamp. Wrap lifeline around chest, passing it under shoulder straps and hoses.

11. ☐ Check air supply and communications. If using the KMB-8 Band Mask, adjust the regulator until a slight steady flow of air enters the mask.

PREDIVE INSPECTION

(To be conducted by the Dive Supervisor)

1. ☐ Verify predive procedures.
2. ☐ Review mission and dive profile.
3. ☐ Check diver's tender.
4. ☐ Hand or attach diver's accessory equipment to diver.
5. ☐ Place diver in water slowly to permit entrapped air to escape suit.

SURFACE CHECKOUT

(To be conducted by the diver upon entering the water)

1. ☐ Swim to the descent line. Check to ensure adequate negative buoyancy. Add or remove weights as necessary.
2. ☐ Adjust air control valve.
3. ☐ Check accessory gear for proper fit.

REPORT ANY MALFUNCTIONS
OR DEFICIENCIES

POSTDIVE PROCEDURES

1. ☐ As the diver leaves the water, the Dive Supervisor is to check him for any signs of sickness or injury that may have resulted from the dive.
2. ☐ Check all diving gear for damage. Clean all diving gear, dry thoroughly and stow in a cool, dry compartment. Check all gear periodically to ensure that it is always ready for immediate use.

UNDERWATER PROCEDURES

DESCENT PROCEDURE

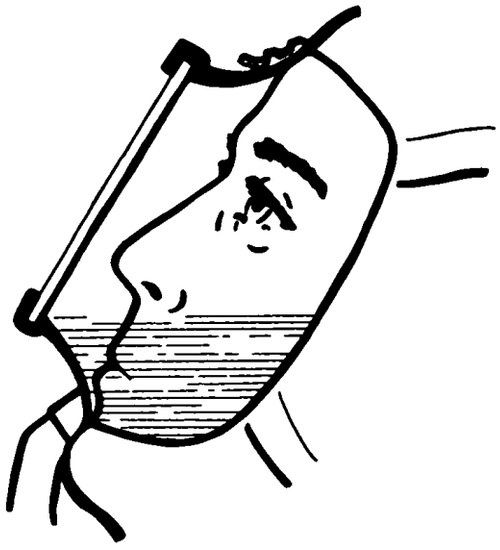
Wrap both legs around the descent line. Holding the line loosely with one hand, descend at a rate not to exceed 75 feet per minute. (The actual rate of descent will depend upon how easily the diver can equalize pressure on both sides of his eardrums). The tender should keep the air hose and lifeline slack at all times during the descent. If the diver stops during the descent, the tender should keep the lines taut, but not strained.

If using the KMB-8 Band Mask, it may be necessary to readjust the regulator by means of the handle during descent. A very slight, steady flow is the best position.

MASK CLEARING

It is possible to flood the lightweight mask up to the level of the exhaust valve. If this should happen, tilt the head back and, while exerting pressure with the palm of the hand on the top of the mask, lift the bottom of the mask to break the face seal. If necessary, increase the air flow slightly to force the water out the bottom of the mask.

The KMB-8 Band Mask may easily be cleared by activating the side valve handle or pressing in on the manual purge in the center of the regulator cover.



VENTILATION PROCEDURES

To keep the carbon dioxide level inside the diver's facemask below a surface equivalent of 2 percent, each diver should be supplied with air according to the following formula:

$$S = 4.5 [(D + 33) / 33]$$

where: S = air supply flow rate in cubic feet per minute measured at atmospheric pressure (scfm).

D = depth in feet

For example, if two divers are working at a depth of 99 feet, each must receive 18 standard cubic feet of air from the surface.

$$S = 4.5 [(99 + 33) / 33] = 18 \text{ scfm}$$

The surface supply, then, must be capable of supplying 2 x 18 = 36 scfm of air to adequately ventilate both divers.

BOTTOM MOVEMENT PROCEDURES

Upon reaching the bottom, the diver should notify topside. The diver should pause as long as necessary to get his bearings. If the worksite is not visible from the descent line, the diver should determine its position relative to either current or sunlight. Before beginning bottom movement, the diver should wrap one turn of the air hose and lifeline around his arm to prevent being thrown off balance by a sudden pull on the line. If a distance line is used, the diver should fasten one end to the descent line and the other end should be tended by the diver, not secured to him.

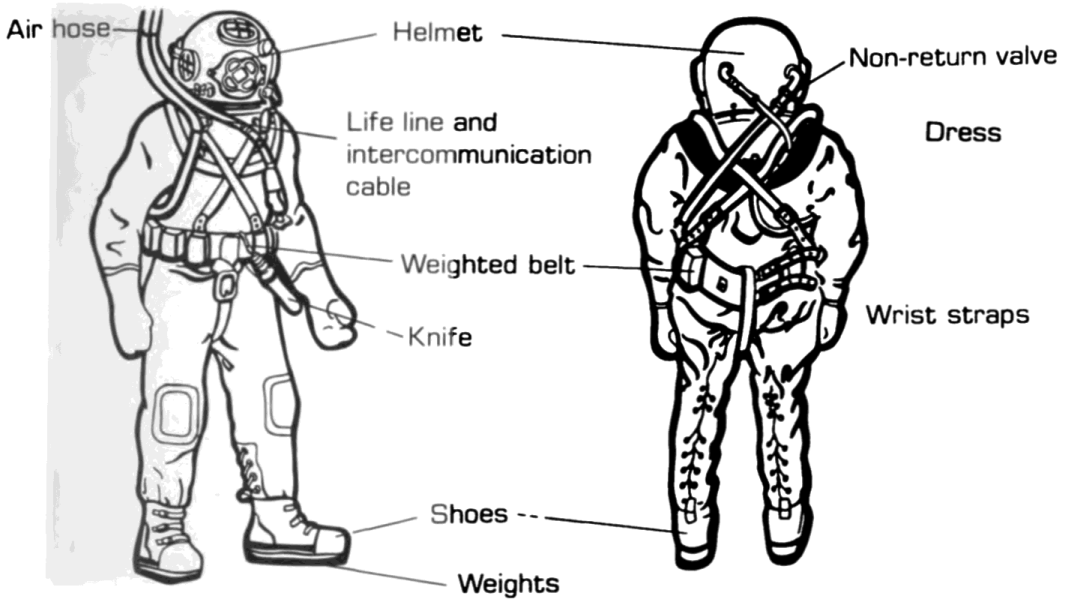
EMERGENCY ASCENT PROCEDURES (KMB-8 Band Mask Only)

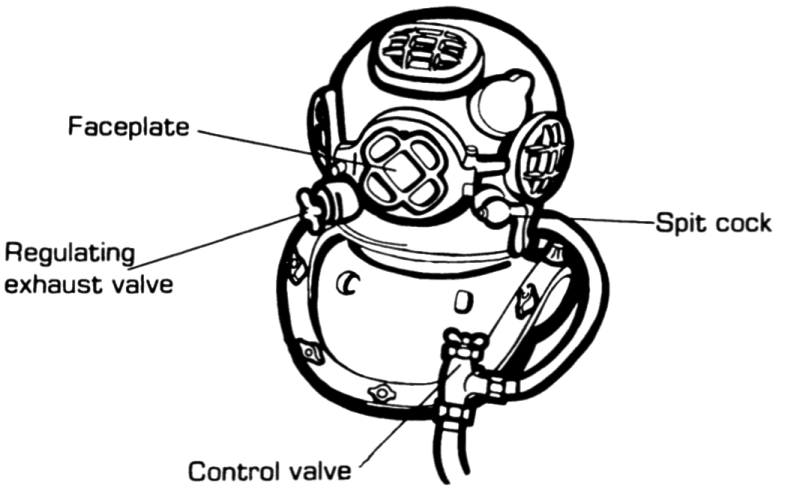
If it is necessary to free ascend due to loss of umbilical air supply, the diver should remove the mask quickly by grasping the main body and pushing out and up. The spider will stretch enough to allow easy removal. The weighted belt should also be dropped. It is important to wear a harness in addition to the weight belt to which the umbilical can be attached. This will allow the diver to drop his weight belt and head for the surface without dropping the mask. If an emergency breathing system is in use with the mask, the diver can activate this system and follow his umbilical back to the working platform.

ASCENT PROCEDURES

When signaled from the surface to "come up" the diver should place all the tools in the toolbag and have them raised to the surface. He then returns to the descent line and checks to ensure that his air hose and lifeline are clear from all obstructions. When prepared to ascend, the diver signals the surface "ready to come up" and the Dive Supervisor signals back "coming up, report when you leave the bottom." Any slack in the lines is taken up and the diver is lifted off the bottom to the first decompression stop at a rate designated by the applicable decompression schedule.

DEEP SEA GEAR





PREDIVE PROCEDURES

(To be conducted by the Dive Supervisor)

1. ☐ Check the primary and auxiliary air supply systems. Rig spare air hose for diver.
2. ☐ Check all air connections.
3. ☐ Check non-return valve.
4. ☐ Attach the air hose and intercommunication cable to the helmet.
5. ☐ Close the control valve. Pressurize air supply hose. Check for leaks. Flush air hose and helmet.
6. ☐ Test diver communications.
7. ☐ Take depth soundings.
8. ☐ Check descent line and stage.
9. ☐ Check that all decompression stops are properly marked.
10. ☐ Check recompression chamber.

ACCESSORY EQUIPMENT

11. ☐ Check all accessory equipment to be used by the diver.

MINIMUM EQUIPMENT

- ☐ Diving dress
- ☐ Underwear
- ☐ Helmet cushion
- ☐ Helmet
- ☐ Lifeline and Airhose
- ☐ Weighted belt
- ☐ Weighted shoes
- ☐ Knife
- ☐ Cuffs/Gloves
- ☐ Pneumofathometer

OPTIONAL EQUIPMENT

- ☐ Overalls
- ☐ Tools/Toolbag
- ☐ Light
- ☐ Slate
- ☐ Other

12. ☐ Dress the diver as per recommended procedures.

PREDIVE INSPECTION

(To be conducted by the Dive Supervisor)

1. ☐ Verify predive procedures.
2. ☐ Have the diver adjust his flow control and exhaust valves.
3. ☐ Check the safety lock on the helmet.
4. ☐ Check that the jock strap to breastplate is tightened down firmly.
5. ☐ Check the communications.
6. ☐ Review the mission and dive profile with diver.
7. ☐ Check the diver's tender.
8. ☐ Place the diver on the stage and hoist him into the water slowly.

SURFACE CHECKOUT

(To be conducted by the diver upon entering the water)

1. ☐ Check to ensure that the dress is airtight.
2. ☐ Check the communications.

   REPORT ANY MALFUNCTIONS OR DEFICIENCIES

3. ☐ Signal when prepared to begin the descent. Upon receiving this signal, the tenders will haul the diver over to the descent line, if stage is not used.

POST DIVE PROCEDURES

1. ☐ As diver leaves the water, the Dive supervisor is to check him for any signs of sickness or injury that may have resulted from the dive.
2. ☐ Check all diving gear for damage. Clean all diving gear and stow in a cool, dry compartment. Check all gear periodically to ensure that it is always ready for immediate use.

UNDERWATER PROCEDURES

DESCENT PROCEDURE

1. If the diver is to descend via a descending line, he wraps his legs firmly around the descent line. Holding the line with one hand, he adjusts the exhaust valve until he is sufficiently negatively buoyant to descend.

2. If the diver is to descend on the stage, he adjusts his buoyancy upon entering the water.

3. The diver descends at a rate not to exceed 75 feet per minute, adjusting the air flow continuously to compensate for the increasing water pressure.

VENTILATION PROCEDURES

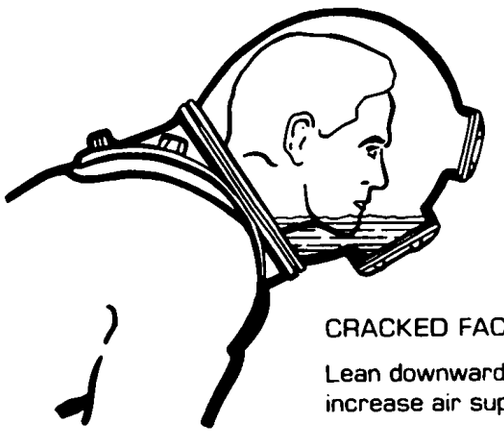
To keep the carbon dioxide level inside the helmet below a surface equivalent of 2 percent, each diver should be supplied with air according to the following formula:

$$S = 4.5\,[(D + 33)/33]$$

where,

S = air supply flow rate in cubic feet per minute at atmospheric pressure (scfm)

D = depth in feet



CRACKED FACEPLATE

Lean downward; increase air supply

BOTTOM PROCEDURES

Upon reaching the bottom, the diver should notify the Dive Supervisor. Holding the descent line for stability, the diver adjusts his buoyancy using either the flow control valve or the chin button, until the helmet merely lifts the weight off his shoulders.

WARNING

Never close the air control valve all the way except when the air supply hose is ruptured or being changed under water.

NOTE

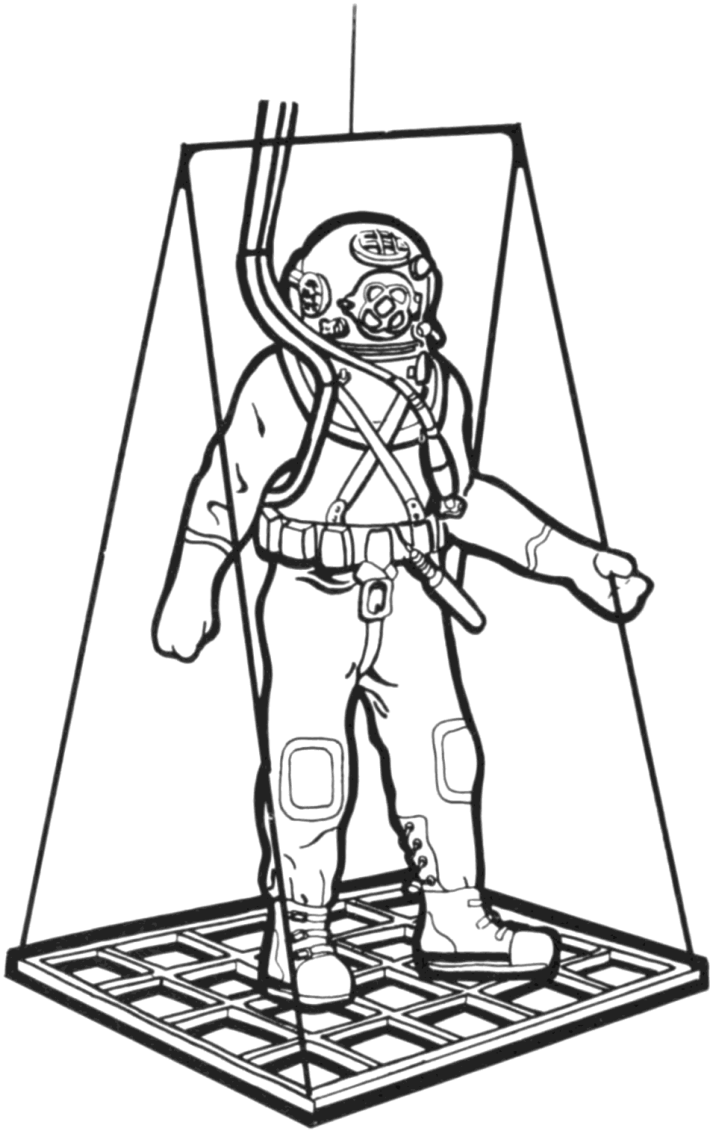
Air entrapped in the diving helmet will last from 6 to 9 minutes, leaving ample time for emergency measures to be executed.

If the worksite is not visible from the descent line, the diver should determine its direction from a prearranged knowledge of its position relative to either current or sunlight. Before beginning bottom movement, the diver should wrap one turn of the hoses around his arm to prevent being thrown off balance by a sudden pull on the line.

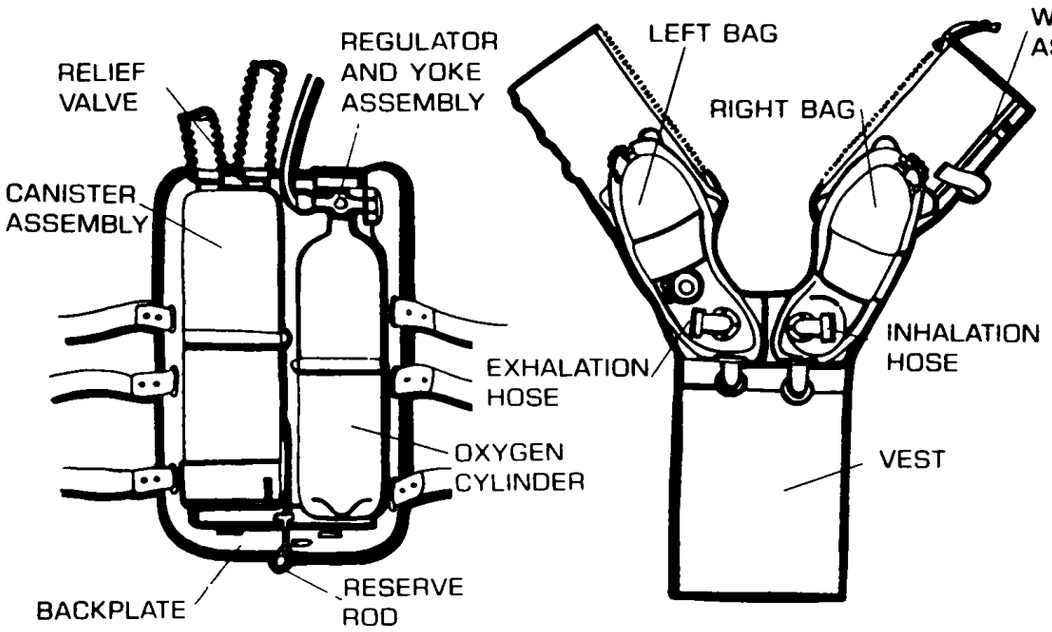
Never get excited. Slow, well planned procedures will generally permit the diver to solve any emergency situation. If a situation should ever present itself that the diver cannot solve himself, the standby diver should be sent down to offer assistance. The standby diver should be prepared to replace the diver's air hose and lifeline, a procedure that may safely be executed on the bottom.

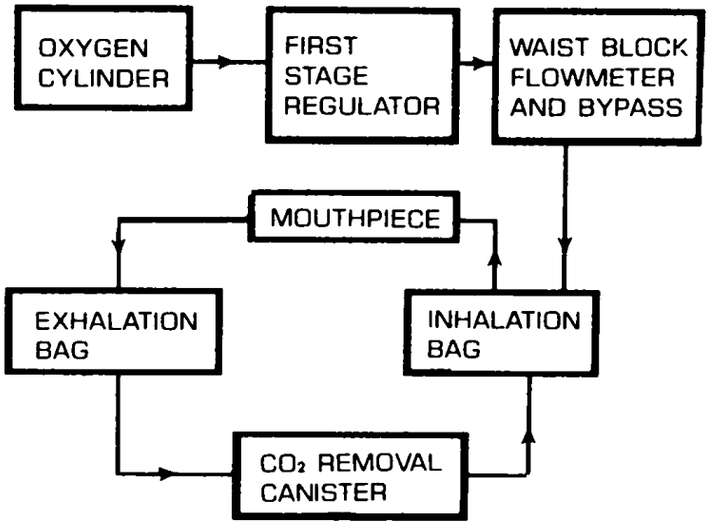
ASCENT PROCEDURES

When signaled from the surface to "come up" the diver should place all the tools in the toolbag and have them raised to the surface. He then returns to the descent line and checks to ensure that his air hose and lifeline are clear from all obstructions. When prepared to ascend, the diver signals the surface "ready to come up" and the Dive Supervisor signals back "coming up, report when you leave the bottom." Any slack in the lines is taken up and the diver is lifted off the bottom to the first decompression stop at a rate designated by the applicable decompression schedule.



OXYGEN RECIRCULATING SCUBA—EMERSON RIG





PREDIVE PROCEDURES

(To be conducted by the Dive Supervisor)

1. ☐ Break out and check all the diving equipment.

MINIMUM EQUIPMENT

- ☐ Swim trunks
- ☐ Closed circuit scuba
- ☐ Mk III yoke type life preserver
- ☐ Facemask
- ☐ Fins
- ☐ Knife

OPTIONAL EQUIPMENT

- ☐ Protective clothing
- ☐ Weightbelt
- ☐ Depth gage
- ☐ Wrist watch
- ☐ Wrist compass
- ☐ Signal flares
- ☐ Floats
- ☐ Slate and stylus
- ☐ Noseclip

2. ☐ Check the main oxygen supply cylinders to ensure that they are properly tagged as "breathing" oxygen. Check the cylinder valves and fittings.
3. ☐ Check the recompression chamber.
4. ☐ Take depth soundings.

EQUIPMENT PREPARATION

(To be conducted by the diver)

1. ☐ Remove the regulator from the cylinder valve, open the reserve valve and charge the cylinder with medically pure oxygen. Maximum charging pressure is 2000 psi.

WARNING
Do not allow oil or grease to come in contact with any of the fittings. Such material, when exposed to high pressure, may explode.

2. ☐ Close the cylinder reserve valve and re-attach the regulator to the cylinder valve.

3. ☐ Remove and fill the CO_2 absorbent canister with Granular Baralyme (about 6 pounds). Replace the canister. Check the duration of the absorbent at water temperature.
4. ☐ Close the mouthpiece valve, charge the breathing bags and immerse the entire apparatus in water. Check for leaks.
5. ☐ Check the inhalation and exhalation hoses' check valves.
6. ☐ Don the apparatus and accessory diving gear.

PREDIVE INSPECTION

(To be conducted by the Dive Supervisor)

1. ☐ Verify equipment preparation.
2. ☐ Check that the metering valve is on the proper setting and that the cylinder valve is open.
3. ☐ Check that the reserve rod is in the start dive position.
4. ☐ Review the mission and dive profile with the diver.
5. ☐ Check the diver's buddy.
6. ☐ Have the diver purge the apparatus and his lungs.

   WARNING

   It is essential that the diver get all the air out of the bags and his lungs. Remaining air could supply a breathable volume of nitrogen after all the oxygen is used up. Unconsciousness or death may result.
7. ☐ When adequately purged, have the diver enter the water.

SURFACE CHECKOUT

(To be conducted by the diver immediately upon entering the water)

1. ☐ Have the buddy diver check the apparatus for leaks.
2. ☐ Check the purge valve.

POSTDIVE PROCEDURES

1. ☐ As the diver leaves the water, the Dive Supervisor is to check him for any signs of sickness or injury that may have resulted from the dive.
2. ☐ Close the cylinder valve and the mouthpiece valve.
3. ☐ Rinse the breathing apparatus and accessory equipment with clean, fresh water.
4. ☐ Remove the CO_2 absorbent canister. Drain out and discard the Baralyme and rinse out the canister. Dry with oil free compressed gas.
5. ☐ Store the scuba in rigid containers in a clean, dry environment. Maintain the apparatus as required to keep it operational at all times.

UNDERWATER PROCEDURES

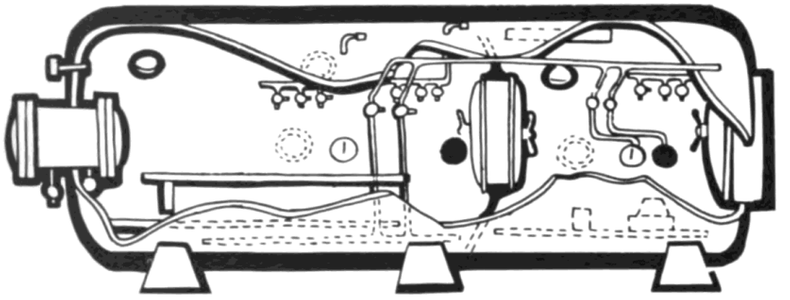
All underwater procedures covered in the section on air scuba apply to closed circuit scuba. In addition:

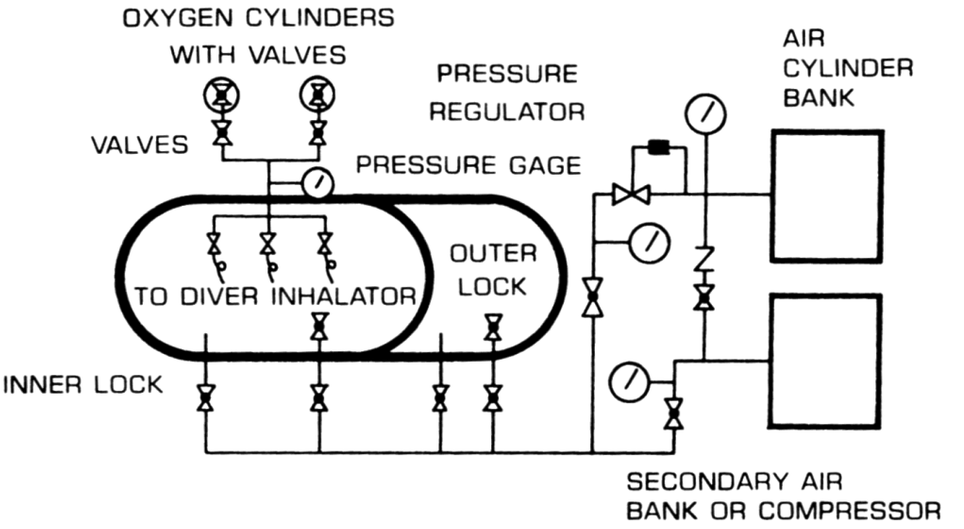
1. ☐ Upon entering the water, have the buddy check the apparatus for leaks.
2. ☐ When comfortable, descend to the directed depth. Use the bypass valve when necessary to prevent breathing bag squeeze.

   CAUTION

   The diver must know and be constantly alert for the symptoms of oxygen poisoning: V-E-N-T-I-D, (Vision-Ears-Nausea-Twitching-Irritability-Dizziness).
3. ☐ Do not dive deeper than 25 feet.
   EXCEPTIONS: (1) limits for exceptional exposure and (2) emergency limits.
4. ☐ While ascending, excess gas must be expelled through the nose or mouth to prevent lung damage and/or embolism.

RECOMPRESSION CHAMBERS





GAS SUPPLY

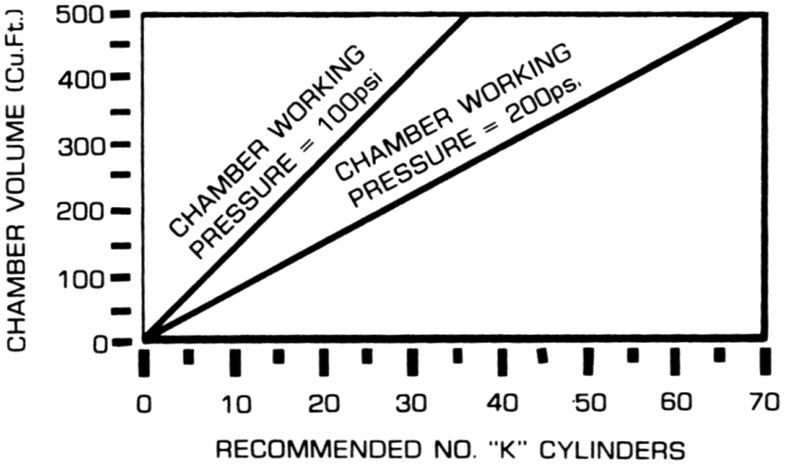
COLOR CODING

All lines should be identified and labeled to indicate function, content, maximum pressure and direction of flow. The color coding of MIL-STD-101B shall be used with the following additions:

Gas System	Designation	Color of Paint
Helium	He	Buff
Oxygen	O_2	Green
Helium-Oxygen Mix	$He\text{-}O_2$	Orange
Nitrogen	N	Light gray
Exhaust	E	Silver
Air (low or high pressure)	ALP, AHP	Black

AIR SUPPLY

A primary and secondary air supply **must** be provided for every recompression chamber. The primary supply, most often a cylinder bank, should contain enough air to pressurize the chamber to its working pressure at least twice. The chart below indicates the recommended number of "K" cylinders, containing 220 SCF each, to adequately support most U.S. Navy recompression chambers. The secondary air supply, usually a compressor, should be capable of pressurizing the chamber to its working pressure at a minimum rate of 50 feet per minute. It should also be capable of charging the primary air supply cylinder bank at a reasonably rapid rate. The air itself must be free of oil, other foreign matter, objectionable gases and odors.



OXYGEN SUPPLY

Unless a central oxygen-distribution system is available, the oxygen supply system must consist of at least two large oxygen cylinders manifolded to the oxygen supply line such that either cylinder may be replaced while the other supplies oxygen. The oxygen must be tagged "breathing oxygen" (see section on gas purity). The piping must be hydrostatically tested and properly cleaned.

HELIUM-OXYGEN SUPPLY

Unless a central $He\text{-}O_2$ supply system is available, the $He\text{-}O_2$ supply should consist of at least two $He\text{-}O_2$ cylinders manifolded to the $He\text{-}O_2$ supply lines such that either cylinder may be replaced while the other supplies $He\text{-}O_2$ to the chamber. The piping must be hydrostatically tested and properly cleaned.

ELECTRICAL SUPPLY

All wiring to the recompression chamber must be of an approved, heavy duty type, armoured or in conduit. All electrical switches must be located outside the chamber.

GENERAL RECOMPRESSION RULES

1. All personnel must be trained in the operation of the recompression equipment and must be able to perform any task required during treatment.
2. Follow the treatment tables accurately. (Tables 1-30 or 1-31)
3. Keep accurate recompression time and records.
4. Do not alter the procedures set forth in the tables EXCEPT 1) when advised to do so by a trained Medical Officer or 2) in an extreme emergency.
5. Assure proper decompression of all personnel entering the chamber.

CHAMBER CHECKOUT PROCEDURE

Prior to each recompression treatment, and at monthly intervals, the following checkout should be conducted:

Communication System:

1. ☐ Primary system operational.
2. ☐ Secondary system operational.

Chamber:

1. ☐ Clean.
2. ☐ Free of all extraneous gear.
3. ☐ Free of noxious odors and/or contaminents.
4. ☐ Medical kit stocked and accessible.
5. ☐ Doors and door seals undamaged, properly installed and lubricated.

Ventilation System:

1. ☐ Valves required for ventilation properly calibrated to indicate the number of turns vs. air volume flow.

Air Supply:

1. ☐ Primary supply; enough air to pressurize chamber to working pressure twice.
2. ☐ Secondary supply operational
3. ☐ Fittings tight, filters clean, valves properly positioned, gages calibrated.

Oxygen Supply

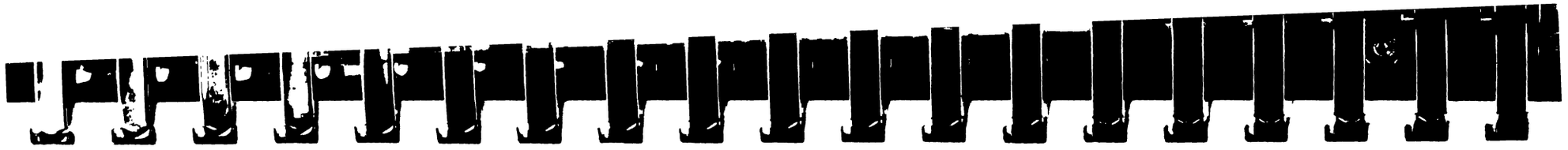
1. ☐ Cylinders full and identified as "breathing oxygen."
2. ☐ Masks installed; inhalators functioning.
3. ☐ Fittings tight, filters clean, valves properly positioned, gages calibrated.
4. ☐ Oxygen elimination system, if installed, operational.

Helium-Oxygen Supply:

1. ☐ Cylinders full.
2. ☐ Fittings tight, filters clean, valves properly positioned, gages calibrated.
3. ☐ Masks installed, inhalators functioning.

Electrical System:

1. ☐ Lights operative.
2. ☐ Properly grounded; wiring approved.
3. ☐ Monitoring equipment calibrated and operational.



Fire Prevention System:

1. ☐ Extinguishing system, if installed, charged and operational.
2. ☐ Water and sand buckets in chamber.
3. ☐ All combustible material enclosed in fireproof jackets.
4. ☐ No chemical fire extinguishers inside chamber.

CHAMBER OPERATING PROCEDURES

Pressurization:

1. The diver and tender must enter the chamber together.
2. The diver should remain relaxed and sit in an uncramped position.
3. The tender closes and gently dogs the outer door.
4. The tender pressurizes the chamber, at a rate of 25 feet per minute, to the depth specified in the appropriate decompression or recompression table.
5. As soon as a seal is obtained about the door, the tender should release the dog.

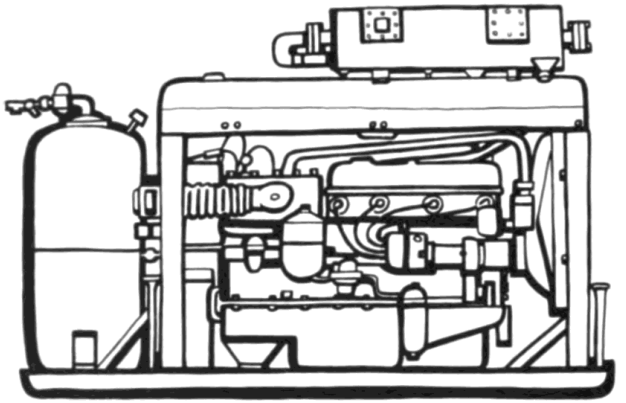
Ventilation:

1. Ventilate the chamber at least one minute out of every five to maintain low temperature and humidity levels, to keep the carbon dioxide level below 1.5 percent and to keep the oxygen level below 25 percent.
2. Ventilation is controlled by the outside tender.
3. If ventilation must be interrupted, the time should not exceed 5 minutes in any 30 minute period. When resumed, use twice the amount of ventilation for twice the period of interruption and then resume with normal ventilation.
4. For chamber occupants breathing air only, provide 2 cubic feet per minute of ventilation for each occupant at rest and 4 cubic feet per minute for each occupant who is not at rest (all volumes are measured at chamber pressure).
5. When oxygen is being breathed, provide 12.5 cubic feet per minute of ventilation for each occupant breathing oxygen at rest and 25 cubic feet per minute for each occupant breathing oxygen who is not at rest. No additional ventilation is required for occupants breathing air. Do not ventilate the chamber if a patient is being treated for oxygen poisoning convulsions.
6. If the chamber has an oxygen level monitoring system, ventilate the chamber as required to keep the oxygen level below 22.5 percent. This rate also requires no additional ventilation for occupants breathing air.
7. If an oxygen elimination system is provided, use the same ventilation rate as would be used if all the occupants were breathing air.
8. Care must be taken when continually venting the chamber to avoid damaging the occupants' ears due to the high noise level. Sound attenuators (drilled to permit pressure equalization) may be worn, but caution must be realized since they are flammable.

Oxygen Breathing:

1. Use oxygen whenever permitted to do so by the tables unless the user is known to be intolerant of oxygen.
2. Adjust the breathing mask so that it seals tightly around the face.
3. Make sure that the tender knows the various symptoms of oxygen poisoning and how to react to each symptom. Remember the symptoms by V-E-N-T-I-D (Vision - Ears - Nausea - Twitching - Irritability - Dizziness).
4. Ventilate the chamber in accordance with the number of occupants breathing oxygen.
5. Be aware of increased fire hazard due to oxygen enriched environments and take all precautions to prevent a fire.

DIVERS AIR SUPPLY



AIR COMPRESSORS

Allowable Depth:

1. The capacity of an air compressor must be known before it is used to supply air for diving. Under no circumstances should divers be permitted to dive beyond the capacity limit of the air compressor.
2. The permissible depth to which one may dive when using an air compressor is determined by the following equation:

$$D = \frac{[(P_c/2) + 7.3]\ Q - 33}{N}$$

where,

D = Maximum allowable diving depth in feet.

P_c = Operating pressure of the compressor in pounds per square inch.

Q = Volume flow rate of the compressor at the operating pressure in cubic feet per minute.

N = Number of divers.

Installation:

1. Locate the inlet to the compressor remote from the exhaust outlet of the compressor engine to prevent contamination of the diver's air.
2. Secure the compressor in position using the lashing rings.

Checkout:

1. ☐ Check the oil in the engine and compressor.
2. ☐ Check the fuel level.
3. ☐ Check that all filters, cleaners and separators are clean.
4. ☐ Check the cooling water.
5. ☐ Check that all fittings are tight, valves properly positioned, and gages calibrated.
6. ☐ Check that the intake hose is clean and located in an atmosphere free from noxious and toxic fumes.
7. ☐ Start the compressor; insure that it is running properly.
8. ☐ Check the secondary air supply. If a compressor is being used, check and start it and leave it running throughout the dive.

Precautions:

1. When using any compressors, the lubrication oil must have a high flash point to prevent combustion. Navy Symbol 219OT, prime oil "D," and castor oil are all approved for this application.
2. If the compressor is of the type that controls humidity, insure that the coolers are periodically drained.
3. Maintain the compressor in first class operating condition.
4. Do not overfill the compressor with oil.
5. Mark all valves "DIVER'S AIR SUPPLY, DO NOT OPEN (OR CLOSE)." Valve positions should not be changed without the approval of the Dive Supervisor.

AIR FLASKS

Duration of supply:

1. The amount of time that a diver may spend on the bottom when using air supplied from a submarine

high pressure air flask can be calculated using the following equation:

$$\text{Number of minutes on bottom} = \frac{CN\,[A - (15 + E + 1)]}{4.5D\,(E + 1)}$$

where,

C = Capacity of one flask in cubic feet of free air (Submarine flasks = 8 cubic feet)

N = Number of flasks (minus one for reserve if a secondary air supply is not available).

A = Gage pressure of air in the flasks in atmospheres (psi divided by 14.7).

E = Gage pressure at depth to which dive is to be made in atmospheres (feet divided by 33).

D = Number of divers.

2. If the depth and duration of the dive are such that decompression is necessary, the length of time spent on the bottom must be reduced to allow sufficient air for decompression. The amount of air required for decompression is the sum of the cubic feet of air used at each stop:

$$\text{Cubic feet of air used at stop} = \left(\frac{SD}{33} + 1\right) 4.5T_{SD}$$

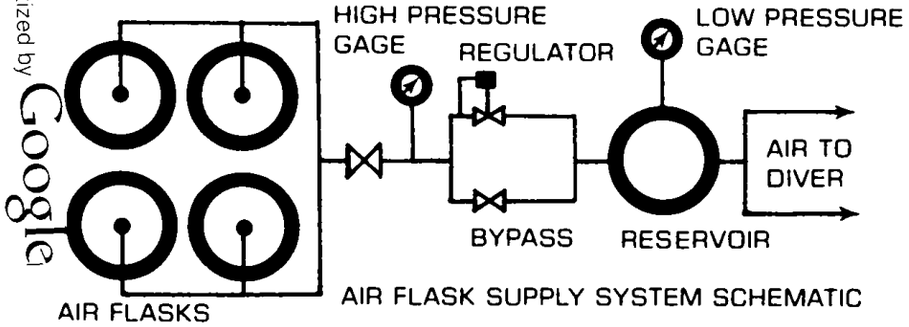
where,

SD = Stop depth in feet

T_{SD} = Duration of time at stop depth plus the ascent time from the preceding stop in minutes.

Installation:

A typical air flask supply system is shown in the figure below. A complete description and bill of materials for this arrangement, may be found in BUSHIPS Plan 19738-S4904-298223 Alt. 1.



AIR FLASK SUPPLY SYSTEM SCHEMATIC

Checkout:

1. ☐ Close all valves, Check that all fittings are tight, filters and strainers are clean and gages calibrated.
2. ☐ Check and record the gage pressure of each flask.
3. ☐ Check that the pressure reducing valve is set at the proper over-bottom pressure (100 psi for dives over 100 feet or 50 psi for dives less than 100 feet).
4. ☐ If a secondary air supply system is not available, check to ensure that one of the flasks is closed off from the system and marked RESERVE.
5. ☐ Ensure that the air flasks are at a temperature that will not cause discomfort to the diver.

Precautions:

1. The pressure in the working flasks must never fall below 220 psi in excess of the pressure at which the divers are working. If the flask pressure approaches this limit, bring the diver up.
2. Do not use the reserve flask until the diver is off the bottom and safely on the way up.
3. A secondary air supply must always be provided. If a separate system is not available, one of the air flasks should be held in reserve as a secondary system.
4. If a compressor is to be used as a secondary air supply, check and start it prior to the dive and leave it running throughout the dive.
5. All valves in the system must be properly color-coded and marked "DIVER'S AIR, DO NOT OPEN (OR CLOSE).

AIR SUPPLY SYSTEM

The space below is allotted for a schematic of the primary and secondary air supply system which is being used during the dive. Simplify the schematic as much as possible, showing only the main components of the system.

COMMUNICATIONS

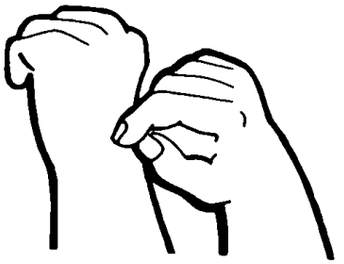
SCUBA HAND SIGNALS

MESSAGES

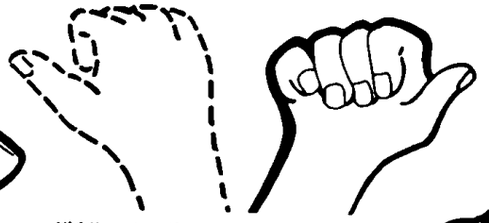
"Let's go up."

"Hold everything."

"All right."

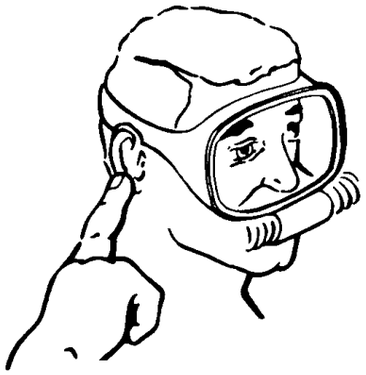


"What time?"

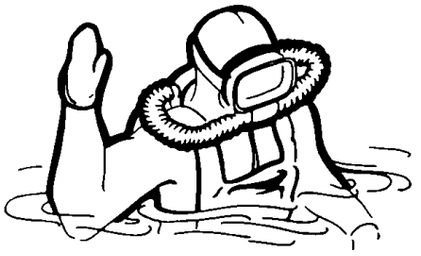


"What direction?"

"I'm having trouble with my air!"

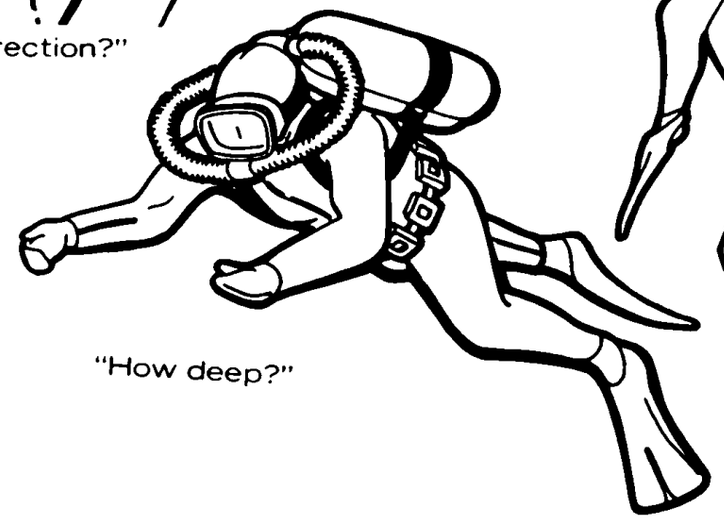


"I'm having trouble with my ears!"



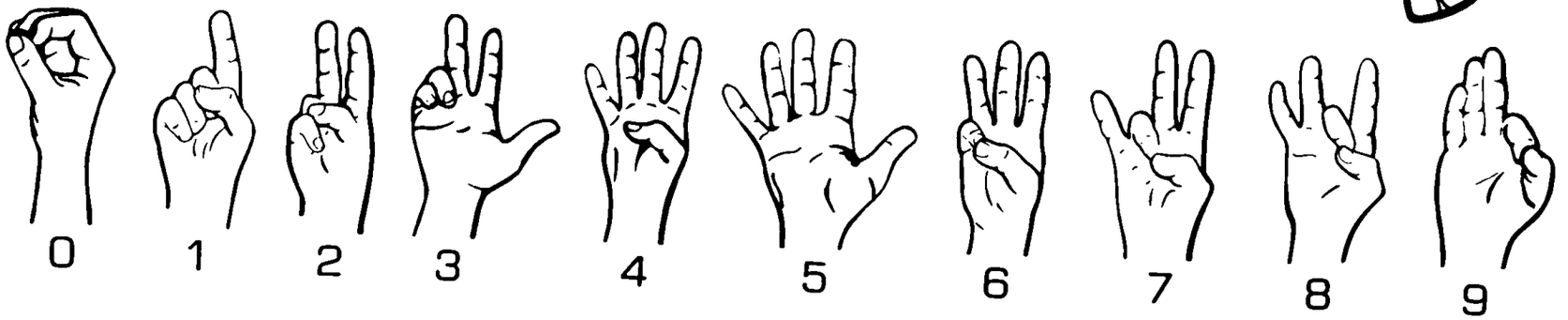
"Pick me up now– Emergency!"

"Pick me up."



"How deep?"

NUMBERS



LINE-PULL SIGNALS

(Signals are to be short and distinct pulls)

SIGNALS FROM TENDER TO DIVER

1 Pull
"Are you all right?" (If diver is descending, 1 pull means "stop").

2 Pulls
"Going down" (During ascent "You have come up too far, go back down until I stop you").

3 Pulls
"Stand by to come up."

4 Pulls
"Come up."

2-1 Pulls
"I understand" or "answer the telephone."

SIGNALS FROM DIVER TO TENDER

1 Pull
"I am all right."

2 Pulls
"Give me slack," or "lower me."

3 Pulls
"Take up my slack."

4 Pulls
"Haul me up."

2-1 Pulls
"I understand" or "answer the telephone."

3-2 Pulls
"Give me more air."

4-3 Pulls
"Give me less air

EMERGENCY SIGNALS FROM THE DIVER

2-2-2 Pulls
"I am fouled and need the assistance of another diver."

3-3-3 Pulls
"I am fouled but can clear myself."

4-4-4 Pulls
"Haul me up immediately."

SEARCHING SIGNALS

(From the tender only)

7 Pulls
"The following signals are searching signals" or if the diver is already using searching signals "Searching signals are to be used no longer."

1 Pull
"Stop and search where you are."

2 Pulls
"Move directly away from the tender if given slack. Move toward the tender if a strain is taken on the life-line. If using a circling line, move away from your weight."

3 Pulls
"Move to your right" (when facing lifeline).

4 Pulls
"Move to your left" (when facing lifeline).

INTERCOMMUNICATION SYSTEM

INSTALLATION

The standard U.S. Navy diving intercommunication system consists of:

Diving Amplifier

Designed to amplify the voice from either the diver or the tender. Includes a combination speaker/microphone, control switches, volume controls, tone controls, power switch, diver's jacks and a grounding binding post. The amplifier operates from power supplies of 12 volts dc, 110 volts dc or 110 volts/60 cycle ac.

Diver's Reproducer

A combination speaker/microphone which mounts in the recess of the diver's helmet. A pair of wires connect the diver's reproducer to the helmet-jack assembly located in the gooseneck.

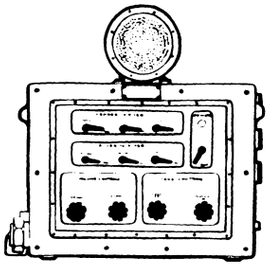
Combination diving amplifier and lifeline cable

A combination electrical conductor cable for communications and strength cable capable of easily withstanding the weight of the diver.

All the cables are equipped with standard plugs to permit their being plugged into the diver's helmet and the amplifier. The 12 volt power cable is provided with battery clips. The 110 volt dc and 110 volt ac power cables have no plugs so that the activity using the intercommunication system may attach the standard fittings that match the available receptacles.

OPERATION:

The diving intercommunication system is designed so that the divers may speak or listen to the talker without manipulating any switches. The amplifier is designed to support three divers. If no switches are pressed, the talker will receive communications from all of the divers. If the talker wishes to speak to one of the divers, he presses the appropriate "tender to diver" switch. If a diver wishes to speak to another diver, the talker presses the appropriate "diver to diver" switch. The volume and tone controls permit the talker to adjust his own and the diver's volume or tone level separately to overcome surrounding noise.



NOTE

It is difficult for the diver to hear the tender because of the high gas noise level. Therefore, the intercommunication system should be used only when rope signals prove inadequate.

TROUBLE SHOOTING CHART

AMPLIFIER FAILURE

1. ☐ Is the power supply energized?
2. ☐ If dc power supply, is the polarity correct?
3. ☐ If battery power supply, are the batteries charged to at least 11.5 v?
4. ☐ Fuse post; blown fuses?
5. ☐ Remove cover. Are there any defective vacuum tubes?
6. ☐ Are there any defective vibrators?
7. ☐ Using the electrical schematic provided with the equipment trace the circuits.
8. ☐ Continuity of power supply cable.

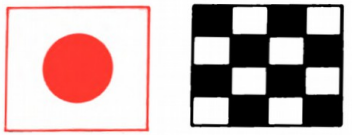
DIVER'S OR TENDER'S REPRODUCER FAILURE

9. ☐ Are connections tight?
10. ☐ Continuity of combination diving amplifier and lifeline cable and jack plug.
11. ☐ Has the reproducer been flooded?
12. ☐ Is the reproducer dirty?

WARNINGS

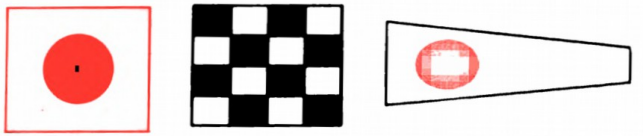
INTERNATIONAL SIGNAL CODE: All signals must be preceeded by the "code" flag to signify that they are international signals.

IN



I require a diver.

IN1

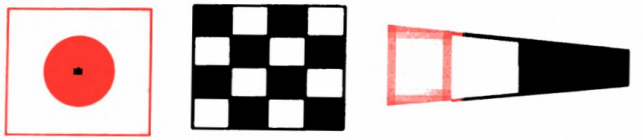


I require a diver to clear my propeller.

IN2

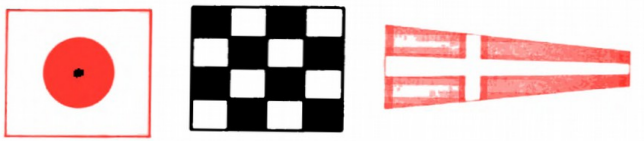
I require a diver to examine bottom.

IN3



I require a diver to place collision mat.

IN4



I require a diver to clear my anchor.

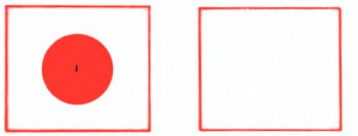
IO

I have no diver.

IP

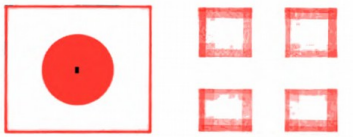
A diver will be sent as soon as possible.

IQ



Diver has been attacked by diver's disease and requires decompression chamber treatment.

IR



I am engaged in submarine survey work. Keep clear of me and go slow.

A

I have a diver down; keep well clear at slow speed.

TENDING DIVERS

When the diver is descending, the tender must keep all slack out of the lines and be ready to render assistance at a moment's notice. **The tender should always be backed up with a second tender to prevent being pulled overboard.**

Once the diver is on the bottom he should be given 2 to 3 feet of slack. This permits the diver to work comfortably but allows the tender to locate him from time to time.

On receiving a signal from the diver, the tender should send the same signal back to the diver only if it is clearly understood. If the signal is not understood, wait until the diver repeats it.

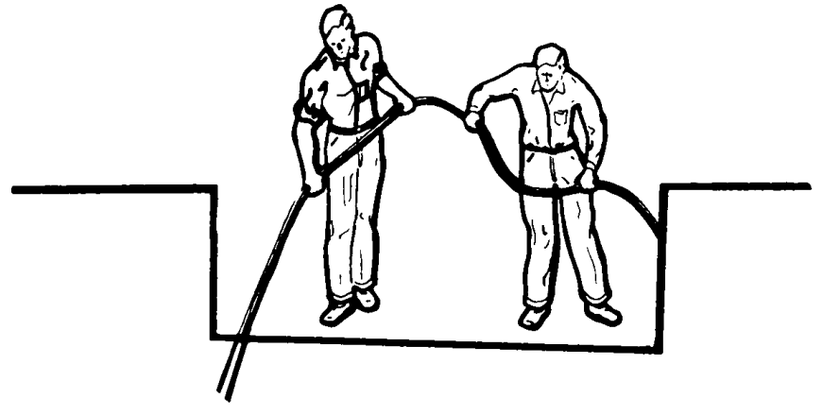
When signaling the diver, the tender must ensure that the diver understands the signal by receiving the same signal back. If a different signal comes back, repeat the correct signal until the diver clearly understands.

If a diver does not answer a signal after two or more trials at short intervals, his condition should be requested over the intercommunication system. Failure to receive a tender's signal could indicate that the lines are too slack, the lines are fouled, the diver's too busy to answer immediately or the diver's in trouble.

If the lines become wrapped around the descending line and cannot be cleared, the tender should pull the diver up to his first decompression stop, descending line and all. The diver, in the meantime, will make every effort to cut the descending line.

If the diver is working clear of the bottom a tight hold should be kept on his lines and a minimum amount of slack let out so that, if the diver falls, the tender will have immediate control of him.

When the diver is ready to ascend the tender should haul him up slowly to his first decompression stop. Hauling should be ceased if the diver becomes too light, but all slack should be taken out of the lines. Upon reaching the first stop, work the diver over to the decompression stage.



DIVER UNDERWATER PROCEDURES

GENERAL

The following list, while not complete, represents the most common situations that an operational diver under water will face. Situations and emergencies will arise that are not covered; however, as is nearly always the case in an underwater emergency, **maintaining self control and using common sense is always the best procedure.**

RATE OF DESCENT

The rate of descent should not exceed 75 ft. per minute, or the rate of descent that the diver can tolerate, which ever is less.

DESCENDING IN TIDEWAY

When descending or ascending in a tideway, the diver should keep his back to the tide so that he will be forced against the descending line and not away from it.

UPON REACHING BOTTOM

Upon reaching bottom, diver should maintain hold of descent line and adjust buoyancy if necessary. He should ventilate and spend adequate time adjusting to the depth level. He should then adjust his air supply for the depth level and anticipated work load conditions. He should periodically ventilate according to work level.

DETERMINE DIRECTION

Before leaving the descent line, the diver should orient himself with respect to the descent line and work location. This may be done by tender-diver communications, by compass, by observing sunlight conditions, or by observing current directions.

MOVEMENT ON BOTTOM

When leaving the descent line, the diver should proceed cautiously to conserve his strength. He should carry one turn of air hose and telephone cable on his arm to prevent being thrown off balance by sudden pulls. As a general rule, the diver should **Pass Over,** not under, projections and obstruction. In passing over any obstruction, the diver should keep in mind the side on which he passes to avoid later fouling on way back.

WORKING ON ROCKY BOTTOM

When working on rocky bottom, the diver should guard against tripping and catching suit or arms and legs in crevices. Gloves should be worn if rocks are sharp. If line becomes fouled, the diver should gather up the lines and retrace his steps. The tender should be alerted regarding the bottom conditions so as to avoid hose damage or fouling.

WORKING ON MUDDY BOTTOM

When working on muddy bottom, the diver should remember to keep all movement to a minimum to avoid stirring up silt and reducing visibility. He may adjust for more positive buoyancy to help this problem. Mud entrapment itself should not present an emergency so long as the diver's equipment is functioning properly. If a cave-in is possible during tunneling operations, a standby diver should be nearby with a second tunneling hose and should tend the tunneling diver's hose.

WORKING AROUND CORNERS OR INSIDE WRECKS

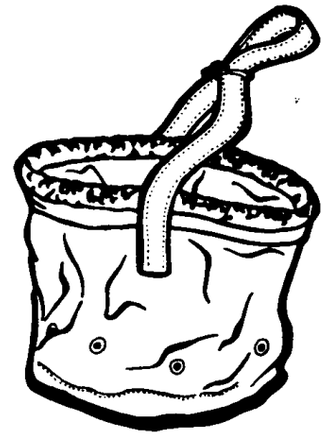
This operation is one of the more hazardous in underwater work. When a diver is required to drag a long length of lifeline and air hose when working around several corners, a standby diver should assist in tending lines. The standby diver is a **requirement** if the diver enters an underwater wreck or tunnel. If fouling occurs, the diver should be familiar with the section on Diver Emergency Procedures. He should only cut lines as a last resort and then only those lines whose function he is absolutely sure of.

WORKING AROUND SEVERAL LINES

When a diver is required to work with several lines, it is a good plan to have them marked for specific purpose. A new line should be lowered in the water prior to actual use to permit initial stretch and shrinkage and obtain its natural configuration. If several divers are in near proximity, care should be taken to prevent hose and line fouling.

SENDING DOWN TOOLS

Definite arrangements should be made by topside personnel to ensure that the diver receives the necessary tools to do a job with the minimum physical strain. Tools that the diver is to carry down should be fitted with lanyards and slipped over the diver's right arm or placed in the diver's toolbag. When tools are not to be carried down by the diver but are to be sent to the diver, a special descending line of 2½ or 3 inch line should be secured to the point where the material is to be used. The line should be given an angle of lead that will cause anything sliding down to land so that the diver can easily locate it and guide it into place. When a power tool is to be sent down, it should precede the diver, and should be attached by a piece of six-thread manila to a sliding shackle on the ascending line, and lowered to the bottom by the tool's air hose. An electric torch and ground wire or a gas torch and igniter can be sent down in the same manner as the power tool, except the ground wire or torch hose is used as the lowering line. For all other objects, use 15 to 21 thread manila for a lowering line, led from well forward to prevent turns, attached by an eye splice to the sliding shackle on the descending line; the small objects are, in turn, attached by a short piece of marline to the shackle.



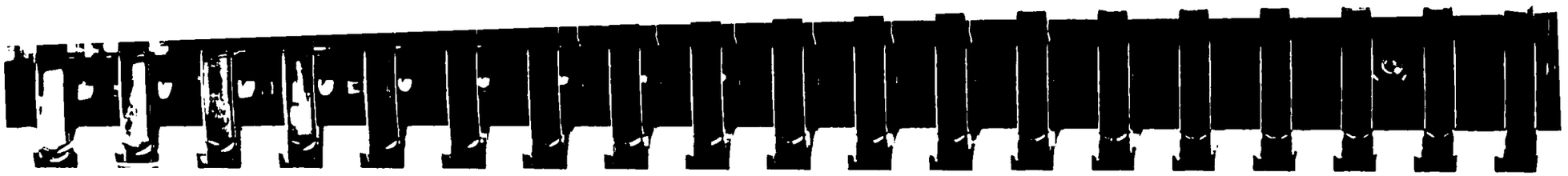
SECTION 3—AIR DECOMPRESSION TABLES

INTRODUCTION

The Air Decompression Tables and Oxygen Limit Tables in this section are the same as those appearing in the USN Diving Manual. Several changes have been made in format to improve readability. Exceptional exposure tables are printed in RED to indicate their use only in emergency situations or exceptional operations. All diving schedules are separated by alternate white and light gray bars to minimize visual overlap.

General instructions for the use of the decompression tables have been rewritten for added clarity. Specific instructions and data which apply to each table are printed at the top of the table and should be completely understood before it is used.

FOLLOW TABLES EXACTLY



DECOMPRESSION OF AIR DIVERS

GENERAL INSTRUCTIONS
NEED FOR DECOMPRESSION

A quantity of nitrogen is absorbed by the divers body tissue during every dive. The amount absorbed depends upon the depth of the dive and the exposure (bottom) time. If the quantity of nitrogen dissolved in the body tissues exceeds a certain critical amount, the divers ascent must be delayed to allow the body tissue to remove the excess nitrogen. Decompression sickness results from failure to delay the ascent and to allow this process of gradual desorption.

DEFINITIONS

SINGLE DIVE
The first dive of the day conducted more than 12 hours after completion of a previous dive.

REPETITIVE DIVE
Any dive performed within 12 hours of a previous dive.

DEPTH
Maximum depth attained in a dive measured in feet of seawater.

BOTTOM TIME
Elapsed time between leaving the surface in descent and leaving the maximum depth in ascent, measured in minutes.

DIVE SCHEDULE
A combination of depth and bottom time as listed in the Decompression Tables; usually indicated by feet/minutes e.g. 150 foot dive, 30 minutes bottom time = 150/30.

DECOMPRESSION STOP
A specified time at a specific depth for purpose of desorption of gases, measured in minutes.

SURFACE INTERVAL
Time spent by diver at surface (atmospheric) pressure between dives or between ascent and repressurization.

RESIDUAL NITROGEN
Nitrogen gas still dissolved in diver's body following completion of a dive.

REPETITIVE GROUP
Letter designation from dive schedule which indicates the amount of residual nitrogen left in the divers body.

RESIDUAL NITROGEN TIME
The additional bottom time which must be added to a repetitive dive to account for the residual nitrogen gas from the previous dive and the loss of nitrogen gas during the surface interval. Residual nitrogen time is expressed as minutes of bottom time at the depth of the repetitive dive.

EQUIVALENT SINGLE DIVE
A single dive for which the bottom time is the sum of residual nitrogen time and actual bottom time of the planned repetitive dive.

APPLICATION OF DECOMPRESSION TABLES

NO-DECOMPRESSION SCHEDULES
Dives that are not long or deep enough to require decompression stops are non-decompression dives. Air dives to 33 feet or less do not require decompression stops. As the depth increases, the allowable bottom time for no-decompression dives decreases. No-decompression dives are listed in Table 1-11 and only require compliance with the 60 feet/minute rate of ascent.

SCHEDULES THAT REQUIRE DECOMPRESSION STOPS
All dives beyond the limits of the no-decompression table require decompression stops.

VARIATIONS IN RATE OF ASCENT

- Ascend from all dives at 60 feet/minute unless otherwise noted.
- If unable to maintain the ascent rate of 60 feet/minute:
  A. If the delay was at a depth greater than 50 feet – Increases the bottom time of the dive by the difference between the time used in ascent and the time that should have been used at a rate of 60 feet/minute. Decompress according to the requirements of the new total bottom time.
  B. If the delay was at a depth less than 50 feet – Increases the first stop by the difference between the time used in ascent and the time that should have been used at the rate of 60 feet/minute.

SPECIFIC INSTRUCTIONS FOR USE OF DECOMPRESSION TABLES

All dives which are not separately listed are covered in the Tables by the next deeper and next longer schedule. **Do Not Interpolate.**

Enter the Tables at the listed depth that is exactly equal to, or is the next greater than, the maximum depth attained during the dive.

Select the bottom time of those listed for the selected depth that is exactly equal to or is next greater than the bottom time of the dive.

Use the decompression stops listed on the line for the selected bottom time.

Insure that the diver's chest is maintained as close as possible to each decompression depth for the number of minutes listed.

Commence timing each stop on arrival and resume ascent when specified time has elapsed.

Observe all special Table instructions.

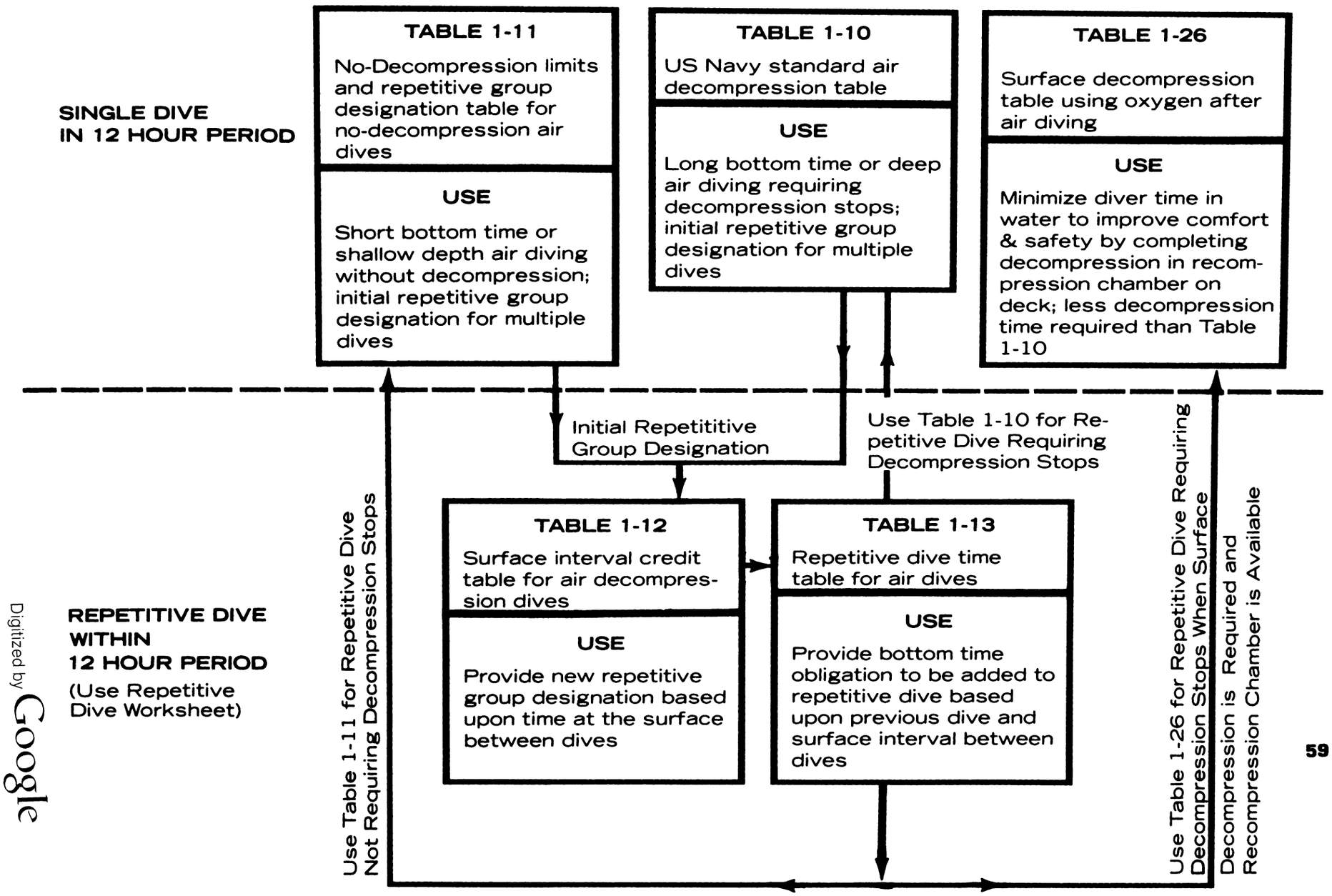
Always fill out Repetitive Dive Worksheet or similar systematic guideline (see Record Keeping Section).

DECOMPRESSION TABLE SELECTOR AIR DIVE

SPECIAL PURPOSE TABLES

TABLE 1-14	TABLE 1-27	TABLE 1-28
U. S. Navy standard air decompression table for exceptional exposures	Surface decompression table using air after air diving	Oxygen depth-time limits
USE	**USE**	**USE**
Emergency or exceptional situations requiring exposures up to 720 min. at 140 feet; depths to 300 feet, not to be used repetitively	Emergency alternative to Table 1-26 in cases of oxygen toxicity or oxygen system failure; surface decompression desired and oxygen not available, no decompression time saving over Table 1-10.	Limitations for operational use of 100% oxygen rebreathing apparatus

NORMAL USE TABLES



REPETITIVE DIVES – The following procedure is used to conduct a repetitive dive:

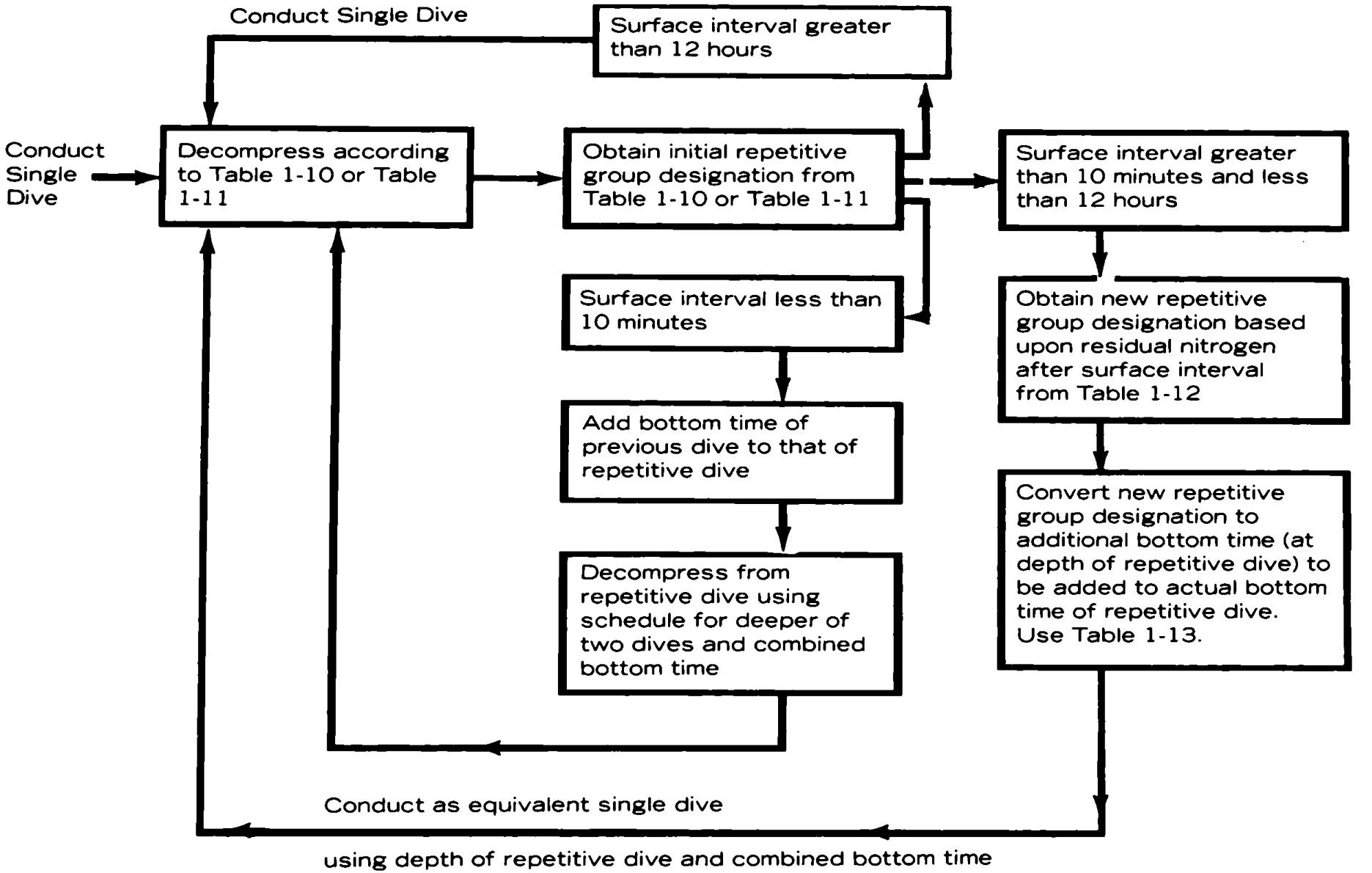


TABLE 1-10 U. S. NAVY STANDARD AIR DECOMPRESSION TABLE

(FORMERLY TABLE 1-5, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

Rate of ascent is not critical between stops for stops of 50 feet or less

If dive was particularly cold or strenuous use next longer bottom time schedule

See Table 1-11 for repetitive groups in no-decompression dives

Depth and bottom time conditions are provided within the limits of Table 1-16 on page 137.

EXAMPLE

Dive to 82 ft. for 36 minutes

1. Select next greater depth = 90 ft.
2. Select next greater bottom time opposite 90 ft. = 40 minutes
3. Stop 7 minutes at 10 ft.

DEPTH	BOTTOM TIME (MINUTES)	TIME TO FIRST STOP MIN.:SEC.	DECOMPRESSION STOPS (FEET) 50	40	30	20	10	TOTAL ASCENT MIN.:SEC.	REPETITIVE GROUP
40	200	0:00					0	0:40	[*]
	210	0:30					2	2:40	N
	230	0:30					7	7:40	N
	250	0:30					11	11:40	O
	270	0:30					15	15:40	O
	300	0:30					19	19:40	Z
50	100	0:00					0	0:50	[*]
	110	0:40					3	3:50	[*]
	120	0:40					5	5:50	M
	140	0:40					10	10:50	M
	160	0:40					21	21:50	N
	180	0:40					29	29:50	O
	200	0:40					35	35:50	O
	220	0:40					40	40:50	Z
	240	0:40					47	47:50	Z

TABLE 1-10 U. S. NAVY STANDARD AIR DECOMPRESSION TABLE

DEPTH	BOTTOM TIME (MINUTES)	TIME TO FIRST STOP MIN.:SEC.	DECOMPRESSION STOPS (FEET) 50	40	30	20	10	TOTAL ASCENT MIN.:SEC.	REPETITIVE GROUP
60	60						0	1:00	[*]
	70	0:50					2	3:00	K
	80	0:50					7	8:00	L
	100	0:50					14	15:00	M
	120	0:50					26	27:00	N
	140	0:50					39	40:00	O
	160	0:50					48	49:00	Z
	180	0:50					56	57:00	Z
	200	0:40				1	69	71:00	Z
70	50						0	1:10	[*]
	60	1:00					8	9:10	K
	70	1:00					14	15:10	L
	80	1:00					18	19:10	M
	90	1:00					23	24:10	N
	100	1:00					33	34:10	N
	110	0:50				2	41	44:10	O
	120	0:50				4	47	52:10	O
	130	0:50				6	52	59:10	O
	140	0:50				8	56	65:10	Z
	150	0:50				9	61	71:10	Z
	160	0:50				13	72	86:10	Z
	170	0:50				19	79	99:10	Z

		50	40	30	20	10		
80	40					0	1:20	[*]
	50	1:10				10	11:20	K
	60	1:10				17	18:20	L
	70	1:10				23	24:20	M
	80	1:00			2	31	34:20	N
	90	1:00			7	39	47:20	N
	100	1:00			11	46	58:20	O
	110	1:00			13	53	67:20	O
	120	1:00			17	56	74:20	Z
	130	1:00			19	63	83:20	Z
	140	1:00			26	69	96:20	Z
	150	1:00			32	77	110:20	Z
90	30					0	1:30	[*]
	40	1:20				7	8:30	J
	50	1:20				18	19:30	L
	60	1:20				25	26:30	M
	70	1:10			7	30	38:30	N
	80	1:10			13	40	54:30	N
	90	1:10			18	48	67:30	O
	100	1:10			21	54	76:30	Z
	110	1:10			24	61	86:30	Z
	120	1:10			32	68	101:30	Z
	130	1:00		5	36	74	116:30	Z
100	25					0	1:40	[*]
	30	1:30				3	4:40	I
	40	1:30				15	16:40	K
	50	1:20			2	24	27:40	L
	60	1:20			9	28	38:40	N
	70	1:20			17	39	57:40	O
	80	1:20			23	48	72:40	O
	90	1:10		3	23	57	84:40	Z
	100	1:10		7	23	66	97:40	Z
	110	1:10		10	34	72	117:40	Z
	120	1:10		12	41	78	132:40	Z

TABLE 1-10 U. S. NAVY STANDARD AIR DECOMPRESSION TABLE

DEPTH	BOTTOM TIME (MINUTES)	TIME TO FIRST STOP MIN.:SEC.	DECOMPRESSION STOPS (FEET) 50	40	30	20	10	TOTAL ASCENT MIN.:SEC.	REPETITIVE GROUP
110	20						0	1:50	[*]
	25	1:40					3	4:50	H
	30	1:40					7	8:50	J
	40	1:30				2	21	24:50	L
	50	1:30				8	26	35:50	M
	60	1:30				18	36	55:50	N
	70	1:20			1	23	48	73:50	O
	80	1:20			7	23	57	88:50	Z
	90	1:20			12	30	64	107:50	Z
	100	1:20			15	37	72	125:50	Z
120	15						0	2:00	[*]
	20	1:50					2	4:00	H
	25	1:50					6	8:00	I
	30	1:50					14	16:00	J
	40	1:40				5	25	32:00	L
	50	1:40				15	31	48:00	N
	60	1:30			2	22	45	71:00	O
	70	1:30			9	23	55	89:00	O
	80	1:30			15	27	63	107:00	Z
	90	1:30			19	37	74	132:00	Z
	100	1:30			23	45	80	150:00	Z
130	10						0	2:10	[*]
	15	2:00					1	3:10	F
	20	2:00					4	6:10	H
	25	2:00					10	12:10	J
	30	1:50				3	18	23:10	M
	40	1:50				10	25	37:10	N
	50	1:40			3	21	37	63:10	O
	60	1:40			9	23	52	86:10	Z
	70	1:40			16	24	61	103:10	Z
	80	1:30		3	19	35	72	131:10	Z
	90	1:30		8	19	45	80	154:10	Z

140

		50	40	30	20	10		
10						0	2:20	[*]
15	2:10					2	4:20	G
20	2:10					6	8:20	I
25	2:00				2	14	18:20	J
30	2:00				5	21	28:20	K
40	1:50			2	16	26	46:20	N
50	1:50			6	24	44	76:20	O
60	1:50			16	23	56	97:20	Z
70	1:40		4	19	32	68	125:20	Z
80	1:40		10	23	41	79	155:20	Z

150

5						0	2:30	C
10	2:20					1	3:30	E
15	2:20					3	5:30	G
20	2:10				2	7	11:30	H
25	2:10				4	17	23:30	K
30	2:10				8	24	34:30	L
40	2:00			5	19	33	59:30	N
50	2:00			12	23	51	88:30	O
60	1:50		3	19	26	62	112:30	Z
70	1:50		11	19	39	75	146:30	Z
80	1:40	1	17	19	50	84	173:30	Z

160

5						0	2:40	D
10	2:30					1	3:40	F
15	2:20				1	4	7:40	H
20	2:20				3	11	16:40	J
25	2:20				7	20	29:40	K
30	2:10			2	11	25	40:40	M
40	2:10			7	23	39	71:40	N
50	2:00		2	16	23	55	98:40	Z
60	2:00		9	19	33	69	132:40	Z

170

5						0	2:50	D
10	2:40					2	4:50	F
15	2:30				2	5	9:50	H
20	2:30				4	15	21:50	J
25	2:20			2	7	23	34:50	L
30	2:20			4	13	26	45:50	M
40	2:10		1	10	23	45	81:50	O
50	2:10		5	18	23	61	109:50	Z
60	2:00	2	15	22	37	74	152:50	Z

TABLE 1-10 U. S. NAVY STANDARD AIR DECOMPRESSION TABLE

DEPTH	BOTTOM TIME [MINUTES]	TIME TO FIRST STOP MIN.:SEC.	DECOMPRESSION STOPS [FEET] 50	40	30	20	10	TOTAL ASCENT MIN.:SEC.	REPETITIVE GROUP
180	5						0	3:00	D
	10	2:50					3	6:00	F
	15	2:40				3	6	12:00	I
	20	2:30			1	5	17	26:00	K
	25	2:30			3	10	24	40:00	L
	30	2:30			6	17	27	53:00	N
	40	2:20		3	14	23	50	93:00	O
	50	2:10	2	9	19	30	65	128:00	Z
190	5						0	3:10	D
	10	2:50				1	3	7:10	G
	15	2:50				4	7	14:10	I
	20	2:40			2	6	20	31:10	K
	25	2:40			5	11	25	44:10	M
	30	2:30		1	8	19	32	63:10	N
	40	2:30		8	14	23	55	103:10	O

TABLE 1-11 NO DECOMPRESSION LIMITS AND REPETITIVE GROUP DESIGNATION TABLE FOR NO DECOMPRESSION AIR DIVES

(FORMERLY TABLE 1-6, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

No-Decompression limits column = allowable maximum bottom time which permits surfacing directly at 60 feet/minute with no decompression stops.

For longer bottom times use the Standard Air Decompression Table (Table 1-10).

Repetitive group designation table = time periods in each vertical column are the maximum exposures at various depths during which a diver will remain within the group listed at the head of the column.

Repetitive group designation: Enter table on exact or next greater depth than exposure and select exposure time exact or next greater than actual exposure time. Read group designation (Letter) at top of column for next dive.

Exposure times beyond 5 hours and less than 40 foot depth are beyond field requirements of this table.

EXAMPLE

A Dive to 32 feet for 45 minutes

1. Select next greater depth = 35 feet
2. Select next greater exposure time than 45 min. = 50 min.
3. Read designation at top of column = Group E

	Designation					
Depth	**A**	**B**	**C**	**D**	**E**	**F**
10	60	120				
15	35	70				
20	25					
25	20	35			Read	
30	15	30				
35	5	15		40	50	60
40		10				
45		10				
50		5				

TABLE 1-11 NO-DECOMPRESSION LIMITS AND REPETITIVE GROUP DESIGNATION TABLE FOR NO-DECOMPRESSION AIR DIVES

(FORMERLY TABLE 1-6, 1963 DIVING MANUAL)

Depth (feet)	No-decompression limits (min)	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
10		60	120	210	300											
15		35	70	110	160	225	350									
20		25	50	75	100	135	180	240	325							
25		20	35	55	75	100	125	160	195	245	315					
30		15	30	45	60	75	95	120	145	170	205	250	310			
35	310	5	15	25	40	50	60	80	100	120	140	160	190	220	270	310
40	200	5	15	25	30	40	50	70	80	100	110	130	150	170	200	
50	100		10	15	25	30	40	50	60	70	80	90	100			
60	60		10	15	20	25	30	40	50	55	60					
70	50		5	10	15	20	30	35	40	45	50					
80	40		5	10	15	20	25	30	35	40						
90	30		5	10	12	15	20	25	30							
100	25		5	7	10	15	20	22	25							
110	20			5	10	13	15	20								
120	15			5	10	12	15									
130	10			5	8	10										
140	10			5	7	10										
150	5			5												
160	5				5											
170	5				5											
180	5				5											
190	5				5											

TABLE 1-12 SURFACE INTERVAL CREDIT TABLE FOR AIR DECOMPRESSION DIVES

(FORMERLY TABLE 1-7, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

Surface interval time in the Table is in hours and minutes (7:59 - 7 hours and 59 minutes).

Surface interval must be at least 10 minutes.

Repetitive group designation after surface interval: Enter Table on diagonal slope using group designation from previous dive. Read horizontally until the actual surface interval is equal to or between interval shown in Table. Read new group designation at top of column.

Dives following surface intervals of more than 12 hours are not repetitive dives. Use actual bottom times in the Standard Air Decompression Tables to compute decompression for such dives.

EXAMPLE

Find new group designation after dive to 110 feet for 30 minutes and a time on the surface of 1 hour and 30 minutes.

1. Previous repetitive group from last column of 110/30 schedule of Standard Air Decompression Table = J.
2. Locate "J" in diagonal column.
3. Follow table across horizontally.
4. The 1 hr. 30 min. interval lies between the times 1:20 and 1:47.
5. Diver has lost sufficient inert gas to place him in group at top of vertical column = G.
6. Use this new group designation to determine Residual Nitrogen Time to be credited toward repetitive dive.

(Repetitive group at the end of the surface interval (air dive))

Repetitive group at the beginning of the surface interval	Z	O	N	M	L	K	J	I	H	G
	0:10	0:23	0:35	0:49	1:03	1:19	1:37	1:56	2:18	2:43
	0:22	0:34	0:48	1:02	1:18	1:36	1:55	2:17	2:42	3:10
O		0:10	0:24	0:37	0:52	1:08	1:25	1:44	2:05	2:30
		0:23	0:36	0:51	1:07	1:24	1:43	2:04	2:29	2:59
	N	0:10	0:25	0:40	0:55	1:12	1:31	1:54	2:19	
		0:24	0:39	0:54	1:11	1:30	1:53	2:18	2:47	
	M	0:10	0:26	0:43	1:00	1:19	1:40	2:06		
		0:25	0:42	0:59	1:18	1:39	2:05	2:34		
	L	0:10	0:27	0:46	1:05	1:26	1:50			
		0:26	0:45	1:04	1:25	1:49	2:19			
	K	0:10	0:29	0:50	1:12	1:36				
		0:28	0:49	1:11	1:35	2:03				
	J	0:10	0:32	0:55	1:20					
		0:31	0:54	1:19	1:47					

TABLE 1-12 SURFACE INTERVAL CREDIT FOR AIR DECOMPRESSION DIVES

(FORMERLY TABLE 1-6, 1963 DIVING MANUAL)

Repetitive group at the beginning of the surface interval

[Repetitive group at the end of the surface interval (air dive)]

	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	
	0:10 0:22	0:23 0:34	0:35 0:48	0:49 1:02	1:03 1:18	1:19 1:36	1:37 1:55	1:56 2:17	2:18 2:42	2:43 3:10	3:11 3:45	3:46 4:29	4:30 5:27	5:28 6:56	6:57 10:05	10:00 12:00*	
O	0:10 0:23	0:24 0:36	0:37 0:51	0:52 1:07	1:08 1:24	1:25 1:43	1:44 2:04	2:05 2:29	2:30 2:59	3:00 3:33	3:34 4:17	4:18 5:16	5:17 6:44	6:45 9:54	9:55 12:00*		**70**
N	0:10 0:24	0:25 0:39	0:40 0:54	0:55 1:11	1:12 1:30	1:31 1:53	1:54 2:18	2:19 2:47	2:48 3:22	3:23 4:04	4:05 5:03	5:04 6:32	6:33 9:43	9:44 12:00*			
M	0:10 0:25	0:26 0:42	0:43 0:59	1:00 1:18	1:19 1:39	1:40 2:05	2:06 2:34	2:35 3:08	3:09 3:52	3:53 4:49	4:50 6:18	6:19 9:28	9:29 12:00*				
L	0:10 0:26	0:27 0:45	0:46 1:04	1:05 1:25	1:26 1:49	1:50 2:19	2:20 2:53	2:54 3:36	3:37 4:35	4:36 6:02	6:03 9:12	9:13 12:00*					
K	0:10 0:28	0:29 0:49	0:50 1:11	1:12 1:35	1:36 2:03	2:04 2:38	2:39 3:21	3:22 4:19	4:20 5:48	5:49 8:58	8:59 12:00*						
J	0:10 0:31	0:32 0:54	0:55 1:19	1:20 1:47	1:48 2:20	2:21 3:04	3:05 4:02	4:03 5:40	5:41 8:40	8:41 12:00*							
I	0:10 0:33	0:34 0:59	1:00 1:29	1:30 2:02	2:03 2:44	2:45 3:43	3:44 5:12	5:13 8:21	8:22 12:00*								
H	0:10 0:36	0:37 1:06	1:07 1:41	1:42 2:23	2:24 3:20	3:21 4:49	4:50 7:59	8:00 12:00*									
G	0:10 0:40	0:41 1:15	1:16 1:59	2:00 2:58	2:59 4:25	4:26 7:35	7:36 12:00*										
F	0:10 0:45	0:46 1:29	1:30 2:28	2:29 3:57	3:58 7:05	7:06 12:00*											
E	0:10 0:54	0:55 1:57	1:58 3:22	3:23 6:32	6:33 12:00*												
D	0:10 1:09	1:10 2:38	2:39 5:48	5:49 12:00*													
C	0:10 1:39	1:40 2:49	2:50 12:00*														
B	0:10 2:10	2:11 12:00*															
A	0:10 12:00*																

Dives following surface intervals of more than 12 hours are not repetitive dives. Use actual bottom times in the Standard Air Decompression Tables to compute decompression for such dives.

TABLE 1-13 REPETITIVE DIVE TIMETABLE FOR AIR DIVES

(FORMERLY TABLE 1-8, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

Bottom times listed in this Table are called "Residual Nitrogen Times."

Residual Nitrogen Time is the time a diver is to consider he has already spent on bottom when a repetitive dive is started to a specific depth.

Residual Nitrogen Time: Enter table horizontally with repetitive group from surface interval credit table. Read directly bottom time to be added to the repetitive dive in the depth column for that dive.

EXAMPLE

The group designation from the surface interval credit table from a previous dive is "H." How much bottom time must be added (Residual Nitrogen Time) for a repetitive dive to 110 feet?

1. Enter Table horizontally at "H."
2. Read in 110 foot depth column residual nitrogen to be added = 27 minutes.
3. The table shows that one must start a dive to 110 feet as though he had already been on the bottom 27 minutes.
4. Use Standard Air Decompression Table or No-Decompression Table to determine dive schedule for repetitive dive.

Repetitive dive depth (ft) (air dives)

Repetitive groups	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
A	7	6	5	4	4	3	3	3	3	3	2	2	2	2	2	2
B	17	13	11	9	8	7	7	6	6	6	5	5	4	4	4	4
C	25	21	17	15	13	11	10	10	9	8	7	7	6	6	6	6
D	37	29	24	20	18	16	14	13	12	11	10	9	9	8	8	8
E	49	38	30	26	23	20	18	16	15	13	12	12	11	10	10	10
F	61	47	36	31	28	24	22	20	18	16	15	14	13	13	12	11
G	73	56	44	37	32	29	26	24	21	19	18	17	15	15	14	13
H	87	66	52	43	38	33	30	27	25	22	20	19	18	17	16	15
I	101	76	61	50	43	38	34	31	28	25	23	22	20	19	18	17
J	116	87	70	57	48	43	38	34	32	28	26	24	23	22	20	19
K	138	99	79	64	54	47	43	38	35	31	29	27	26	24	22	21
L	161	111	88	72	61	53	48	42	39	35	32	30	28	26	25	24
M	187	124	97	80	68	58	52	47	43	38	35	32	31	29	27	26
N	213	142	107	87	73	64	57	51	46	40	38	35	33	31	29	28
O	241	160	117	96	80	70	62	55	50	44	40	38	36	34	31	30
Z	257	169	122	100	84	73	64	57	52	46	42	40	37	35	32	31

TABLE 1-14 U. S. NAVY STANDARD AIR DECOMPRESSION TABLE FOR EXCEPTIONAL EXPOSURES

(FORMERLY TABLE 1-9, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

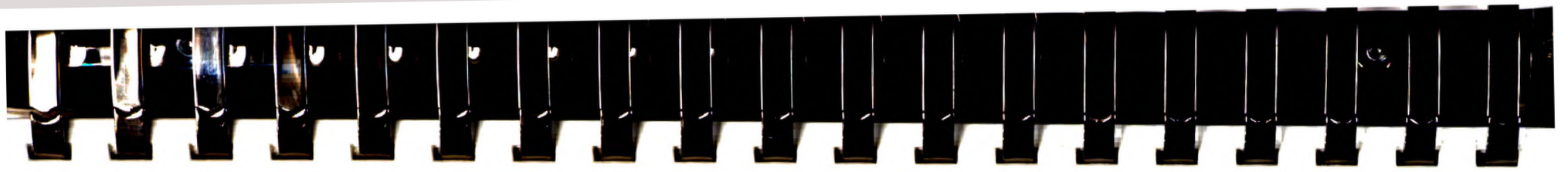
The Table includes only Schedules of Decompression for exceptional or emergency cases.

The great demands placed upon a diver's endurance by emergencies necessitating the use of this Table are such that complete assurance of success of the decompression schedules is impossible.

Never follow a dive covered by this Table with a repetitive dive. 72

The Diving Officer must weigh the need for any dive in this Table for exceptional exposures against the increased danger and demands on the diver's physical endurance.

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Decompression stops (feet) 130	120	110	100	90	80	70	60	50	40	30	20	10	Total ascent time (min:sec)
40	360	0:30													23	23:40
	480	0:30													41	41:40
	720	0:30													69	69:40
60	240	0:40												2	79	82:00
	360	0:40												20	119	140:00
	480	0:40												44	148	193:00
	720	0:40												78	187	266:00
80	180	1:00												35	85	121:20
	240	0:50											6	52	120	179:20
	360	0:50											29	90	160	280:20
	480	0:50											59	107	187	354:20
	720	0:40										17	108	142	187	455:20
100	180	1:00											29	53	118	202:40
	240	1:00										14	42	84	142	283:40
	360	0:50									2	42	73	111	187	416:40
	480	0:50									21	61	91	142	187	503:40
	720	0:50									55	106	122	142	187	613:40



			130	120	110	100	90	80	70	60	50	40	30	20	10	
120	120	1:20										10	19	47	98	176:00
	180	1:10									5	27	37	76	137	284:00
	240	1:10									23	35	60	97	179	396:00
	360	1:00								18	45	64	93	142	187	551:00
	480	0:50							3	41	64	93	122	142	187	654:00
	720	0:50							32	74	100	114	122	142	187	773:00
140	90	1:30									2	14	18	42	88	166:20
	120	1:30									12	14	36	56	120	240:20
	180	1:20								10	26	32	54	94	168	386:20
	240	1:10							8	28	34	50	78	124	187	511:20
	360	1:00						9	32	42	64	84	122	142	187	684:20
	480	1:00						31	44	59	100	114	122	142	187	801:20
	720	0:50					16	56	88	97	100	114	122	142	187	924:20
160	70	1:50									1	17	22	44	80	166:40
170	70										8	17	19	51	86	183:50
	90	1:50								12	12	14	34	52	120	246:50
	120	1:30						2	10	12	18	32	42	82	156	356:50
	180	1:20					4	10	22	28	34	50	78	120	187	535:50
	240	1:20					18	24	30	42	50	70	116	142	187	681:50
	360	1:10				22	34	40	52	60	98	114	122	142	187	873:50
	480	1:00			14	40	42	56	91	97	100	114	122	142	187	1007:50
180	60										5	16	19	44	81	168:00
190	50	2:20									4	13	22	33	72	147:10
	60										10	17	19	50	84	183:10
200	5	3:10													1	4:20
	10	3:00												1	4	8:20
	15	2:50											1	4	10	18:20
	20	2:50											3	7	27	40:20
	25	2:50											7	14	25	49:20
	30	2:40										2	9	22	37	73:20
	40	2:30									2	8	17	23	59	112:20
	50	2:30									6	16	22	39	75	161:20
	60	2:20								2	13	17	24	51	89	199:20
	90	1:50					1	10	10	12	12	30	38	74	134	324:20
	120	1:40				6	10	10	10	24	28	40	64	98	180	473:20
	180	1:20		1	10	10	18	24	24	42	48	70	106	142	187	685:20
	240	1:20		6	20	24	24	36	42	54	68	114	122	142	187	842:20
	360	1:10	12	22	36	40	44	56	82	98	100	114	122	142	187	1058:20

TABLE 1-14 U. S. NAVY STANDARD AIR DECOMPRESSION TABLE FOR EXCEPTIONAL EXPOSURES

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Decompression stops (feet)													Total ascent time (min:sec)
			130	120	110	100	90	80	70	60	50	40	30	20	10	
210	5	3:20													1	4:30
	10	3:10												2	4	9:30
	15	3:00											1	5	13	22:30
	20	3:00											4	10	23	40:30
	25	2:50										2	7	17	27	56:30
	30	2:50										4	9	24	41	81:30
	40	2:40									4	9	19	26	63	124:30
	50	2:30								1	9	17	19	45	80	174:30
220	5	3:30													2	5:40
	10	3:20												2	5	10:40
	15	3:10											2	5	16	26:40
	20	3:00										1	3	11	24	42:40
	25	3:00										3	8	19	33	66:40
	30	2:50									1	7	10	23	47	91:40
	40	2:50									6	12	22	29	68	140:40
	50	2:40								3	12	17	18	51	86	190:40
230	5	3:40													2	5:50
	10	3:20											1	2	6	12:50
	15	3:20											3	6	18	30:50
	20	3:10										2	5	12	26	48:50
	25	3:10										4	8	22	37	74:50
	30	3:00									2	8	12	23	51	99:50
	40	2:50								1	7	15	22	34	74	156:50
	50	2:50								5	14	16	24	51	89	202:50
240	5	3:50													2	6:00
	10	3:30											1	3	6	14:00
	15	3:30											4	6	21	35:00
	20	3:20										3	6	15	25	53:00
	25	3:10									1	4	9	24	40	82:00
	30	3:10									4	8	15	22	56	109:00
	40	3:00								3	7	17	22	39	75	167:00
	50	2:50							1	8	15	16	29	51	94	218:00

			130	120	110	100	90	80	70	60	50	40	30	20	10	
250	5	3:50												1	2	7:10
	10	3:40											1	4	7	16:10
	15	3:30										1	4	7	22	38:10
	20	3:30										4	7	17	27	59:10
	25	3:20									2	7	10	24	45	92:10
	30	3:20									6	7	17	23	59	116:10
	40	3:10								5	9	17	19	45	79	178:10
	60	2:40					4	10	10	10	12	22	36	64	126	298:10
	90	2:10		8	10	10	10	10	10	28	28	44	68	98	186	514:10
260	5	4:00														
	10	3:50												1	2	7:20
	15	3:40											2	4	9	19:20
	20	3:30										2	4	10	22	42:20
	25	3:30									1	4	7	20	31	67:20
	30	3:20									3	8	11	23	50	99:20
	40	3:10								2	6	8	19	26	61	126:20
									1	6	11	16	19	49	84	190:20
270	5	4:10														
	10	4:00												1	3	8:30
	15	3:50											2	5	11	22:30
	20	3:40										3	4	11	24	46:30
	25	3:30									2	3	9	21	35	74:30
	30	3:30								2	3	8	13	23	53	106:30
	40	3:20								3	6	12	22	27	64	138:30
									5	6	11	17	22	51	88	204:30
280	5	4:20														
	10	4:00												2	2	8:40
	15	3:50										1	2	5	13	25:40
	20	3:50									1	3	4	11	26	49:40
	25	3:40									3	4	8	23	39	81:40
	30	3:30								2	5	7	16	23	56	113:40
	40	3:20							1	3	7	13	22	30	70	150:40
								1	6	6	13	17	27	51	93	218:40
290	5	4:30														
	10	4:10												2	3	9:50
	15	4:00										1	3	5	16	29:50
	20	4:00									1	3	6	12	26	52:50
	25	3:50									3	7	9	23	43	89:50
	30	3:40								3	5	8	17	23	60	120:50
	40	3:30							1	5	6	16	22	36	72	162:50
								3	5	7	15	16	32	51	95	228:50

TABLE 1-14 U. S. NAVY STANDARD AIR DECOMPRESSION TABLE FOR EXCEPTIONAL EXPOSURES

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Decompression stops (feet) 130	120	110	100	90	80	70	60	50	40	30	20	10	Total ascent time (min:sec)
300	5	4:40												3	3	11:00
	10	4:20										1	3	6	17	32:00
	15	4:10									2	3	6	15	26	57:00
	20	4:00								2	3	7	10	23	47	97:00
	25	3:50							1	3	6	8	19	26	61	129:00
	30	3:50							2	5	7	17	22	39	75	172:00
	40	3:40						4	6	9	15	17	34	51	90	231:00
	60	3:00		4	10	10	10	10	10	14	28	32	50	90	187	460:00

Extreme exposures—250 and 300 ft

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Decompression stops (feet) 200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	Total ascent time (min:sec)
250	120	1:50							5	10	10	10	10	16	24	24	36	48	64	94	142	187	684:10
	180	1:30					4	8	8	10	22	24	24	32	42	44	60	84	114	122	142	187	931:10
	240	1:30					9	14	21	22	22	40	40	42	56	76	98	100	114	122	142	187	1109:10
300	90	2:20					3	8	8	10	10	10	10	16	24	24	34	48	64	90	142	187	693:00
	120	2:00			4	8	8	8	8	10	14	24	24	24	34	42	58	66	102	122	142	187	890:00
	180	1:40	6	8	8	8	14	20	21	21	28	40	40	48	56	82	98	100	114	122	142	187	1168:00

TABLE 1-26 SURFACE DECOMPRESSION TABLE USING OXYGEN

(FORMERLY TABLE 1-17, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

The use of surface decompression provides the advantages of added comfort and security for the diver.

Routine use of this technique requires a recompression chamber equipped with proper oxygen breathing equipment. Use of this Table may be indicated in certain emergency situations where a surface interval **must** come between the dive and the major part of decompression. Although it is possible for the decompression period following the surface interval to be in the water, recompression in a chamber is always preferable.

In the event of oxygen toxicity symptoms, or failure of the oxygen supply, decompress according to Table 1-27 disregarding time spent on oxygen.

Use of this technique exposes the diver to a brief surface interval between his leaving the water and his attaining the scheduled decompression stop depth in the recompression chamber. The interval **must** be as short as possible.

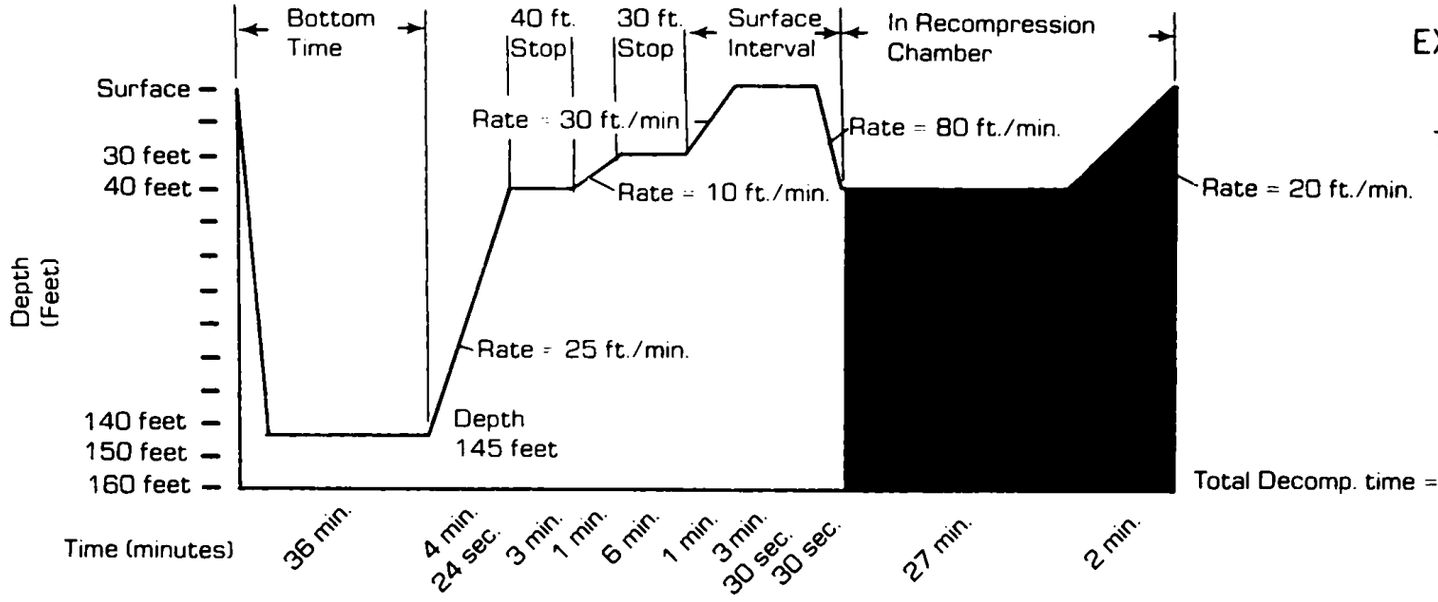
When surface decompression is to be used, this Table is employed in place of the standard Air Decompression Table, Table 1-10.

Column No. 3–time of ascent to the first stop or to the surface at a rate of 25 feet/minute.

Column No. 4–Water Stops: Time spent at tabulated stops using air. If no stops are required ascend to surface at 25 feet/minute. When stops are required, use a 25 foot/minute ascent rate to first stop. Take an additional minute between stops. Ascend from 30 foot stop to surface at 30 feet/minute.

Column No. 5–Surface Interval: Surface interval shall not exceed 5 minutes and includes 1 minute ascent from 30 foot stop, 3 minutes 30 seconds for landing the diver on deck and undressing, and time of descent from surface to 40 feet in recompression chamber (30 seconds).

Column No. 6–During the period of oxygen breathing, the chamber should be ventilated unless an oxygen elimination system is used.



EXAMPLE PROFILE

DECOMPRESS USING

THE 150/40 SCHEDULE

TABLE 1-26 SURFACE DECOMPRESSION TABLE USING OXYGEN

1	2	3	4				5	6	7	8
			Time (min) breathing air at water stops (ft)							
Depth (feet)	Bottom time (min)	Time to first stop or surface (min:sec)	60	50	40	30	Surface interval	Time at 40-foot chamber stop (min) on oxygen	Surface	Total decompression time (min:sec)
70	52	2:48	0	0	0	0		0		2:48
	90	2:48	0	0	0	0		15		23:48
	120	2:48	0	0	0	0		23		31:48
	150	2:28	0	0	0	0		31		39:48
	180	2:48	0	0	0	0		39		47:48
80	40	3:12	0	0	0	0		0		3:12
	70	3:12	0	0	0	0		14		23:12
	85	3:12	0	0	0	0		20		29:12
	100	3:12	0	0	0	0		26		35:12
	115	3:12	0	0	0	0		31		40:12
	130	3:12	0	0	0	0		37		46:12
	150	3:12	0	0	0	0		44		53:12
90	32	3:36	0	0	0	0		0		3:36
	60	3:36	0	0	0	0		14		23:36
	70	3:36	0	0	0	0		20		29:36
	80	3:36	0	0	0	0		25		34:36
	90	3:36	0	0	0	0		30		39:36
	100	3:36	0	0	0	0		34		43:36
	110	3:36	0	0	0	0		39		48:36
	120	3:36	0	0	0	0		43		52:36
	130	3:36	0	0	0	0		48		57:36
100	26	4:00	0	0	0	0		0		4:00
	50	4:00	0	0	0	0		14		24:00
	60	4:00	0	0	0	0		20		30:00
	70	4:00	0	0	0	0		26		36:00
	80	4:00	0	0	0	0		32		42:00
	90	4:00	0	0	0	0		38		48:00
	100	4:00	0	0	0	0		44		54:00
	110	4:00	0	0	0	0		49		59:00
	120	4:00	0	0	0	0		53		63:00

SURFACE INTERVAL NOT TO EXCEED 5 MINUTES

2-MINUTE ASCENT FROM 40 FEET IN CHAMBER TO SURFACE WHILE BREATHING OXYGEN

110

22	4:24	0	0	0	0	0	4:24
40	4:24	0	0	0	0	12	22:24
50	4:24	0	0	0	0	19	29:24
60	4:24	0	0	0	0	26	36:24
70	4:24	0	0	0	0	33	43:24
80	3:12	0	0	0	1	40	51:12
90	3:12	0	0	0	2	46	58:12
100	3:12	0	0	0	5	51	66:12
110	3:12	0	0	0	12	54	76:12

120

18	4:48	0	0	0	0	0	4:48
30	4:48	0	0	0	0	9	19:48
40	4:48	0	0	0	0	16	26:48
50	4:48	0	0	0	0	24	34:48
60	3:36	0	0	0	2	32	44:36
70	3:36	0	0	0	4	39	53:36
80	3:36	0	0	0	5	46	61:36
90	3:12	0	0	3	7	51	72:12
100	3:12	0	0	6	15	54	86:12

130

15	5:12	0	0	0	0	0	5:12
30	5:12	0	0	0	0	12	23:12
40	5:12	0	0	0	0	21	32:12
50	4:00	0	0	0	3	29	43:00
60	4:00	0	0	0	5	37	53:00
70	4:00	0	0	0	7	45	63:00
80	3:36	0	0	6	7	51	75:36
90	3:36	0	0	10	12	56	89:36

140

13	5:36	0	0	0	0	0	5:36
25	5:36	0	0	0	0	11	22:36
30	5:36	0	0	0	0	15	26:36
35	5:36	0	0	0	0	20	31:36
40	4:24	0	0	0	2	24	37:24
45	4:24	0	0	0	4	29	44:24
50	4:24	0	0	0	6	33	50:24
55	4:24	0	0	0	7	38	56:24
60	4:24	0	0	0	8	43	62:24
65	4:00	0	0	3	7	48	70:00
70	3:36	0	2	7	7	51	79:36

SURFACE INTERVAL NOT TO EXCEED 5 MINUTES

2-MINUTE ASCENT FROM 40 FEET IN CHAMBER TO SURFACE WHILE BREATHING OXYGEN

TABLE 1-26 SURFACE DECOMPRESSION TABLE USING OXYGEN

1	2	3	4				5	6	7	8
			Time (min) breathing air at water stops (ft)							
Depth (feet)	Bottom time (min)	Time to first stop or surface (min:sec)	60	50	40	30	Surface interval	Time at 40-foot chamber stop (min) on oxygen	Surface	Total decompression time (min:sec)
150	11	6:00	0	0	0	0	SURFACE INTERVAL NOT TO EXCEED 5 MINUTES	0	2-MINUTE ASCENT FROM 40 FEET IN CHAMBER TO SURFACE WHILE BREATHING OXYGEN	6:00
	25	6:00	0	0	0	0		13		25:00
	30	6:00	0	0	0	0		18		30:00
	35	4:48	0	0	0	4		23		38:48
	40	4:24	0	0	3	6		27		48:24
	45	4:24	0	0	5	7		33		57:24
	50	4:00	0	2	5	8		38		66:00
	55	3:36	2	5	9	4		44		77:36
160	9	6:24	0	0	0	0		0		6:24
	20	6:24	0	0	0	0		11		23:24
	25	6:24	0	0	0	0		16		28:24
	30	5:12	0	0	0	2		21		35:12
	35	4:48	0	0	4	6		26		48:48
	40	4:24	0	3	5	8		32		61:24
	45	4:00	3	4	8	6		38		73:00
170	7	6:48	0	0	0	0		0		6:48
	20	6:48	0	0	0	0		13		25:48
	25	6:48	0	0	0	0		19		31:48
	30	5:12	0	0	3	5		23		44:12
	35	4:48	0	4	4	7		29		57:48
	40	4:24	4	4	8	6		36		72:24

TABLE 1-27 SURFACE DECOMPRESSION TABLE USING AIR FOR AIR DIVING

(FORMERLY TABLE 1-18, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

This Table may be used for surface decompression from an air dive in the event that oxygen toxicity or failure of the oxygen supply prevent the use of Table 1-26.

When surface decompression on air is to be used, this Table is employed in place of the Standard Air Decompression Table – Table 1-10.

If this Table is used as a result of oxygen toxicity problems with Table 1-26, disregard previous time spent on oxygen when decompressing according to this schedule.

There is no surface decompression schedule for use following a dive on the Standard Air Decompression Table for Exceptional Exposures, Table 1-14.

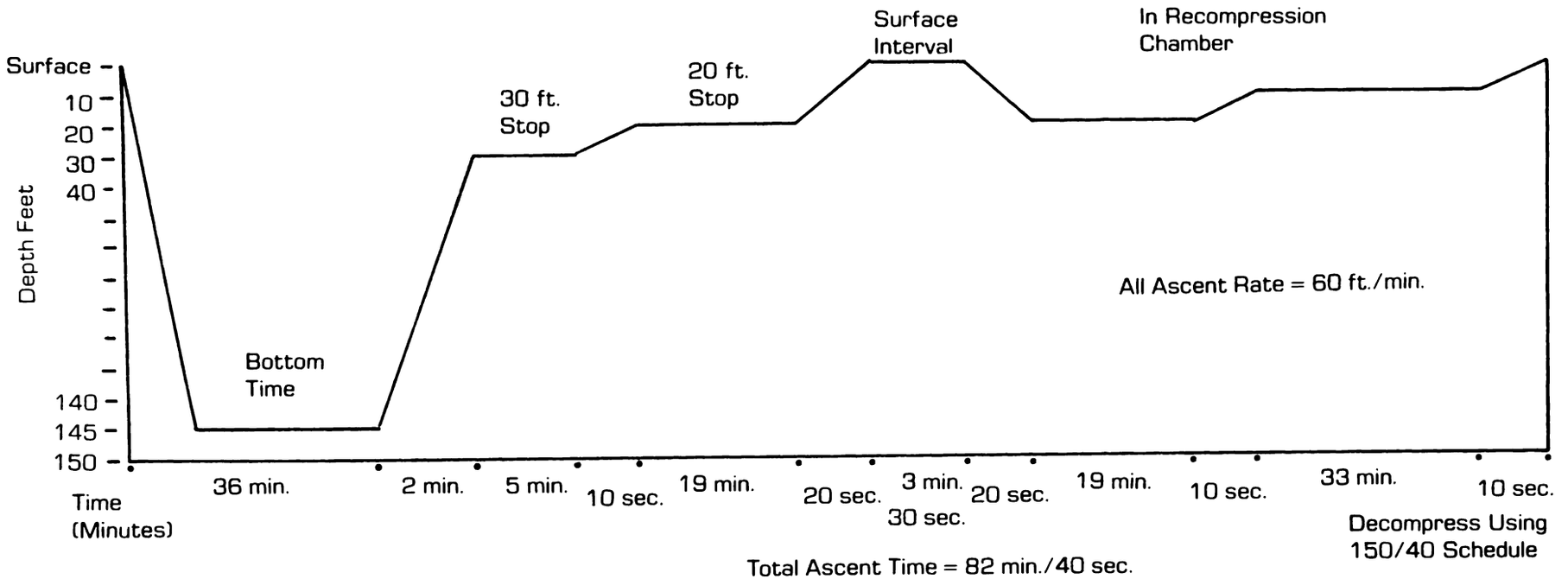
All ascent and descent rates are 60 feet/minute.

Do not exceed the 3 minutes 30 seconds time limit on the surface.

No time saving results from use of this Table in place of the Standard Air Decompression Table, comfort and security of the diver are the only advantages.

EXAMPLE

Using the surface decompression technique with air determine the dive profile for an air dive to 145 feet and a bottom time of 36 minutes.



Total Ascent Time = 82 min./40 sec.

TABLE 1-27 SURFACE DECOMPRESSION TABLE USING AIR

(FORMERLY TABLE 1-18, 1963 DIVING MANUAL)

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Time at water stops (min) 30	20	10	Surface Interval	Chamber stops (air) (min) 20	10	Total ascent time (min:sec)
40	230	0:30			3			7	14:30
	250	:30			3			11	18:30
	270	:30			3			15	22:30
	300	:30			3			19	26:30
50	120	:40			3			5	12:40
	140	:40			3			10	17:40
	160	:40			3			21	28:40
	180	:40			3			29	36:40
	200	:40			3			35	42:40
	220	:40			3			40	47:40
	240	:40			3			47	54:40
60	80	:50			3			7	14:50
	100	:50			3			14	21:50
	120	:50			3			26	33:50
	140	:50			3			39	46:50
	160	:50			3			48	55:50
	180	:50			3			56	63:50
	200	:40		3		TIME ON SURFACE NOT TO EXCEED 3 MINUTES AND 30 SECONDS	3	69	80:10
70	60	1:00			3			8	16:00
	70	1:00			3			14	22:00
	80	1:00			3			18	26:00
	90	1:00			3			23	31:00
	100	1:00			3			33	41:00
	110	:50		3			3	41	52:20
	120	:50		3			4	47	59:20
	130	:50		3			6	52	66:20
	140	:50		3			8	56	72:20
	150	:50		3			9	61	78:20
	160	:50		3			13	72	93:20
	170	:50		3			19	79	106:20

80

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Time at water stops (min) 30	20	10	Surface	Chamber stops (air) (min) 20	10	Total ascent time (min:sec)
	50	1:10			3			10	25:10
	60	1:10			3			17	31:10
	70	1:10			3			23	42:30
	80	1:00		3			3	31	54:30
	90	1:00		3			7	39	65:30
	100	1:00		3			11	46	74:30
	110	1:00		3			13	53	81:30
	120	1:00		3			17	56	90:30
	130	1:00		3			19	63	126:30
	140	1:00		26			26	69	146:30
	150	1:00		32			32	77	

TIME ON SURFACE NOT TO EXCEED 3 MINUTES AND 30 SECONDS

90

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Time at water stops (min) 40	30	20	10	Surface	Chamber stops (air) (min) 20	10	Total ascent time (min:sec)
	40	1:20				3			7	15:20
	50	1:20				3			18	26:20
	60	1:20				3			25	33:20
	70	1:10		3				7	30	45:40
	80	1:10		13				13	40	71:40
	90	1:10		18				18	48	89:40
	100	1:10		21				21	54	101:40
	110	1:10		24				24	61	114:40
	120	1:10		32				32	68	137:40
	130	1:00	5	36				36	74	156:40

TIME ON SURFACE NOT TO EXCEED 3 MINUTES AND 30 SECONDS

100

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Time at water stops (min) 50	40	30	20	10	Surface	Chamber stops (air) (min) 20	10	Total ascent time (min:sec)
	40	1:30					3			15	23:30
	50	1:20				3			3	24	35:50
	60	1:20				3			9	28	45:50
	70	1:20				3			17	39	64:50
	80	1:20				23			23	48	99:50
	90	1:10			3	23			23	57	111:50
	100	1:10			7	23			23	66	124:50
	110	1:10			10	34			34	72	155:50
	120	1:10			12	41			41	78	177:50

TIME ON SURFACE NOT TO EXCEED 3 MINUTES AND 30 SECONDS

110

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Time at water stops (min) 30	20	10	Surface	Chamber stops (air) (min) 20	10	Total ascent time (min:sec)
	30	1:40			3			7	15:40
	40	1:30		3			3	21	33:00
	50	1:30		3			8	26	43:00
	60	1:30		18			18	36	78:00
	70	1:20	1	23			23	48	101:00
	80	1:20	7	23			23	57	116:00
	90	1:20	12	30			30	64	142:00
	100	1:20	15	37			37	72	167:00

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Time at water stops (min) 50	40	30	20	10	Surface interval	Surface	Chamber stops (air) (min) 20	10	Total ascent time (min:sec)
120	25	1:50					3				6	14:50
	30	1:50					3				14	22:50
	40	1:40				3			5		25	39:10
	50	1:40				15			15		31	67:10
	60	1:30			2	22			22		45	97:10
	70	1:30			9	23			23		55	116:10
	80	1:30			15	27			27		63	138:10
	90	1:30			19	37			37		74	173:10
	100	1:30			23	45			45		80	189:10
130	25	2:00					3				10	19:00
	30	1:50				3			3		18	30:20
	40	1:50				10			10		25	51:20
	50	1:40			3	21			21		37	88:20
	60	1:40			9	23			23		52	113:20
	70	1:40			16	24			24		61	131:20
	80	1:30		3	19	35			35		72	170:20
	90	1:30		8	19	45			45		80	203:20
140	20	2:10					3				6	15:10
	25	2:00				3			3		14	26:30
	30	2:00				5			5		21	37:30
	40	1:50			2	16			16		26	66:30
	50	1:50			6	24			24		44	104:30
	60	1:50			16	23			23		56	124:30
	70	1:40		4	19	32			32		68	161:30
	80	1:40		10	23	41			41		79	200:30

TIME ON SURFACE NOT TO EXCEED 3 MINUTES AND 30 SECONDS

			50	40	30	20	10			
150	20	2:10				3		3	7	19:40
	25	2:10				4		4	17	31:40
	30	2:10				8		8	24	46:40
	40	2:00			5	19		19	33	82:40
	50	2:00			12	23		23	51	115:40
	60	1:50		3	19	26		26	62	142:40
	70	1:50		11	19	39		39	75	189:40
	80	1:40	1	17	19	50		50	84	227:40
160	20	2:20				3		3	11	23:50
	25	2:20				7		7	20	40:50
	30	2:10			2	11		11	25	55:50
	40	2:10			7	23		23	39	98:50
	50	2:00		2	16	23		23	55	125:50
	60	2:00		9	19	33		33	69	169:50
	70	1:50	1	17	22	44		44	80	214:50
170	15	2:30				3		3	5	18:00
	20	2:30				4		4	15	30:00
	25	2:20			2	7		7	23	46:00
	30	2:20			4	13		13	26	63:00
	40	2:10		1	10	23		23	45	109:00
	50	2:10		5	18	23		23	61	137:00
	60	2:00	2	15	22	37		37	74	194:00
	70	2:00	8	17	19	51		51	86	239:00
180	15	2:40				3		3	6	19:10
	20	2:30			1	5		5	17	35:10
	25	2:30			3	10		10	24	54:10
	30	2:30			6	17		17	27	74:10
	40	2:20		3	14	23		23	50	120:10
	50	2:10	2	9	19	30		30	65	162:10
	60	2:10	5	16	19	44		44	81	216:10
190	15	2:50				4		4	7	22:20
	20	2:40			2	6		6	20	41:20
	25	2:40			5	11		11	25	59:20
	30	2:30		1	8	19		19	32	86:20
	40	2:30		8	14	23		23	55	130:20
	50	2:20	4	13	22	33		33	72	184:20
	60	2:20	10	17	19	50		50	84	237:20

TIME ON SURFACE NOT TO EXCEED 3 MINUTES AND 30 SECONDS

TABLE 1-28 OXYGEN DEPTH-TIME LIMITS

(FORMERLY TABLE 1-19, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

This Table defines depth and time limits of exposure for breathing pure oxygen during **working dives.**

Oxygen toxicity is an ever present danger when using pure oxygen in working dives. Review all information in the 1970 Diving Manual, Par. 1.3.11 before diving with a high partial pressure of oxygen.

The normal limit is simply defined – DO NOT DIVE DEEPER THAN 25 FEET.

Use of the limits for exceptional operations may be authorized by the Diving Officer when he has weighed his operational objectives against the increased hazards and has taken all precautions possible.

1. Normal

Depth (ft)	Time (min)
10	240
15	150
20	110
25	75

2. Limits for exceptional operations:

Depth (ft)	Time (min)
30	45
35	25
40	10

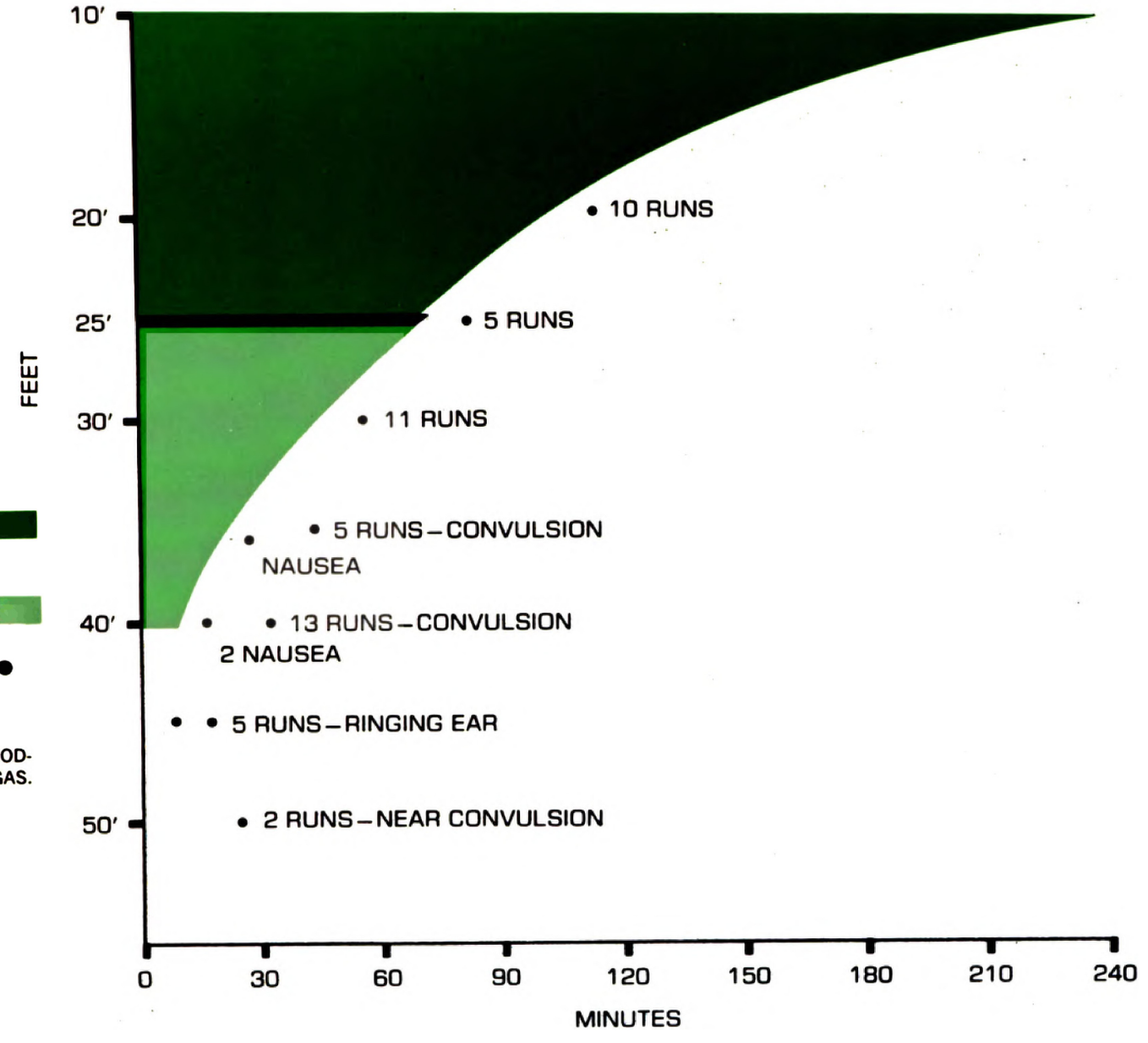
EMERGENCY LIMITS

Extraordinary situations, such as extremely important missions when oxygen is the only breathing medium that can be used, may dictate exceeding the limits of Table 1-28. The chart below is provided to graphically illustrate the increased risks involved.

The graph is based upon experiments conducted under ideal laboratory conditions. It is likely that exposure to oxygen at similar depths for the same time under actual operating conditions would produce a much larger proportion of unfavorable effects.

The necessity to exceed the limits of Table 1-28 in order to accomplish a mission must be brought to the attention of the Officer assigning the mission, who must accept the responsibility for the increased hazard to personnel.

BREATHING 100% O_2 DEPTH/TIME LIMITS



NORMAL OPERATIONS* DEPTH/TIME LIMITS

SPECIAL OPERATIONS* DEPTH/TIME LIMITS

EFFECTS NOTED BEYOND LIMITS ●

* CONSIDERED SAFE FOR DIVES INVOLVING MODERATE WORK WITH MINIMAL CO_2 IN INSPIRED GAS.

SECTION 4—EMERGENCY PROCEDURES

INTRODUCTION

Before initiating any diving operation be completely familiar with the information in this section. Although the information and rules in this section are taken from the Diving Manual, they are in condensed form for simplicity and rapid use. In all emergency situations REMAIN CALM. Use your judgement, experience, and available equipment and information carefully. When in doubt, seek assistance quickly.

The Diver Injury section covers injuries which can befall diving personnel which are **not treated by recompression**. First Aid Procedures provide instructions for life saving techniques.

The Underwater Emergency Procedures charts provide the recommended procedures for the most common situations. The chart for Diagnosis of Decompression Sickness provides a simplified relationship of symptoms and signs to probable causes to assist in establishing treatment. The Rules For Recompression Treatment are based upon years of Navy experience and should not be violated.

Recompression treatment procedures have been changed in this Handbook to reflect the improved treatment experienced using the oxygen treatment tables. These tables may now be used without a medical officer present provided he is in telephone communications with the facility giving treatment. Recommended treatment chart on page 101 is found by consecutively lifting the leaves of the Treatment Procedure chart. Procedures for handling recurrence of symptoms **during** treatment are found by following the chart. Procedures for handling a recurrence **after** completion of initial treatment are on a separate chart.

REMAIN CALM

DIVER INJURIES

NON-RECOMPRESSION TREATMENT

The following diagnosis and treatment procedures apply to the most common types of diver injuries which do not require recompression treatment. Management of traumatic injuries should be accomplished using standard Navy first aid procedures.

SQUEEZE

Definition

Squeeze occurs whenever fixed volume gas spaces within the body or diving gear are not pressure counterbalanced to surrounding depth. Pain is caused by compression of tissues and, if the pressure difference is allowed to increase, by the hemorrhage and rupture of blood vessels.

TYPES & SYMPTOMS

Ear Squeeze

Caused by inability to equalize middle-ear space as a result of obstructed eustachian tube. Severe ear pain. Ruptured ear drum resulting from squeeze which allows entrance of cold water to inner ear can cause extreme dizziness (vertigo), nausea and possible vomiting.

Sinus Squeeze

Caused by inability to equalize sinus spaces in the skull as a result of obstruction of passages which connect with the nasal cavity. Severe pain in sinus areas around nose and eyes. Swelling of lining tissues and (if the pressure difference is high enough) hemorrhage into the sinus spaces can cause blood and mucous to discharge from nose.

Face or Body Squeeze

Caused by sudden non-equalization of facemask, suit, or hardhat resulting from failure of surface gas supply and non-functioning of non-return valve, or rapid increase in depth without compensating gas pressure. Pain caused by local tissue compression and possible hemorrhage of blood vessels in affected tissue. Bleeding into skin, around eyes or from nose may occur.

Thoracic (Lung) Squeeze

Caused by compression of lungs to less than their residual volume resulting from an extremely deep skin dive (breath holding) or pronounced body squeeze. May produce significant lung damage due to blood and tissue fluids being forced into the alveoli and uncompensated air passages. Breathing difficulty and bloody, frothy sputum may be noted.

TREATMENT

Re-establish pressure balance as quickly as possible. Stop descent and attempt to equalize. If unable to compensate pressure, ascend to the surface—do not continue deeper.

RESPIRATORY PROBLEMS

Definition

Respiratory problems include those conditions in which irregular or arrested respiration results from:

1. Inadequate ventilation due to low oxygen levels or the inability to remove carbon dioxide, or
2. Presence of levels of toxic gases which cause lung irritation or interfere with respiration or metabolism.

TYPES & SYMPTOMS

Hypoxia (Shortage of Oxygen)

Caused by failure of the tissue cells to receive enough oxygen from the inspired gas to maintain their normal function. Results from loss of mouthpiece or surface air supply or inadequate gas flow in closed and semi-closed apparatus. Severe hypoxia produces rapid unconsciousness. Gradual hypoxia produces effects similar to alcoholic intoxication—inability to think clearly, loss of coordination, confusion, euphoria.

Carbon Dioxide Excess

Caused by interference with the body's transport and elimination of carbon dioxide resulting from inadequate ventilation of mask or helmet, failure of the carbon dioxide absorption system in closed and semi-closed apparatus or excessive dead space in breathing apparatus. Symptoms include mental confusion, shortness of

breath, headache, dizziness, nausea, weakness and unconsciousness.

Carbon Monoxide Poisoning
Caused by the presence of high carbon monoxide levels in the inspired air which results in reduction of the blood's capacity to carry oxygen. Normally results from induction of engine exhaust fumes into compressor intakes supplying diver's air. Symptoms progress from headache, nausea, abnormal redness of lips and fingernails, respiratory arrest to unconsciousness.

Toxic/Irritant Vapor Inhalation
Caused by the inspiration of toxic fumes, usually volatile vapors from liquid storage or noxious gases, encountered in closed spaces. Symptoms include dizziness, headache, nausea, weakness, unpleasant taste or smell, chest pain, coughing, and unconsciousness.

Near Drowning
Caused by the inspiration of water into the lungs and associated hypoxia resulting from exhaustion, loss or flooding of mask, mouthpiece or helmet, failure of gear or gas supply. Symptoms include coughing, gurgling chest sounds, and unconsciousness.

TREATMENT
Switch to fresh breathing gas and ascend. Examine diver to ensure clear airway. If breathing is irregular upon surfacing, administer 100% oxygen. If breathing has stopped, immediately initate mouth-to-mouth resuscitation.

OXYGEN TOXICITY (POISONING)

Definition
Oxygen toxicity can occur from the inspiration of oxygen at partial pressures greater than 0.6 atmospheres and is of two types. The first is lung irritation caused by exposures of many hours or days to 0.6 atmospheres or more of oxygen. The second type, which produces central nervous system symptoms, can occur after short exposures to oxygen partial pressures of about 1.6 atmospheres or higher. The lower the partial pressure in both situations the longer will be the time before symptoms develop.

Occurance
Oxygen toxicity may occur when breathing pure oxygen at pressure and also when breathing nitrogen-oxygen and helium-oxygen mixtures. Operationally, high oxygen partial pressures are most likely to be encountered in the use of closed and semi-closed apparatus, helium-oxygen equipment, and during saturation diving or oxygen administration as part of recompression treatment.

CONTRIBUTING FACTORS
Exertion
Heavy work will significantly reduce the time of onset of symptoms.

Excess Carbon Dioxide
High levels of carbon dioxide in the lungs from heavy exertion or other causes can hasten the development of toxicity.

Individual Differences
Individuals vary in their susceptibility to oxygen poisoning.

Symptoms
One or more of the following symptoms may be observed: Muscle twitching (most common), nausea, dizziness, abnormalities of vision or hearing, breathing difficulty, confusion, incoordination, lung irritation, and convulsions (seizures).

TREATMENT
Heed the warning of early symptoms. Reduce exertion. If in water, ascend to shallower depth or surface to reduce partial pressure. Switch to mixture of lower oxygen concentration if possible. If in chamber, stop mask breathing and breathe chamber atmosphere. Hyperventilate on new breathing gas. If convulsions occur in chamber, protect diver from thrashing against hard objects and chewing tongue.

MOUTH-TO-MOUTH RESUSCITATION

1. LIFT NECK

Lift the neck and extend the head to open air passage.

2. EXTEND HEAD

Draw down the victim's lower lip. Pull chin upward until head is tilted back fully. Pinch off the nostrils with your other hand, this prevents air leakage when inflating the lungs.

3. INFLATE LUNGS

Place your mouth over the mouth of an adult or large child. For a small child place your mouth over both the nose and mouth. Make a tight seal and blow into the air passages until the chest rises. Infants and small children only need small puffs of air. Remove your mouth and let the patient breathe out through his nose or mouth. Continue this at the rate of 10-12 times per minute for an adult, and at least 20 times a minute for a child. For Mouth to Nose Resuscitation, inflate the lungs through the nose, keeping the mouth closed.

HEART-LUNG RESUSCITATION
Call doctor at once.

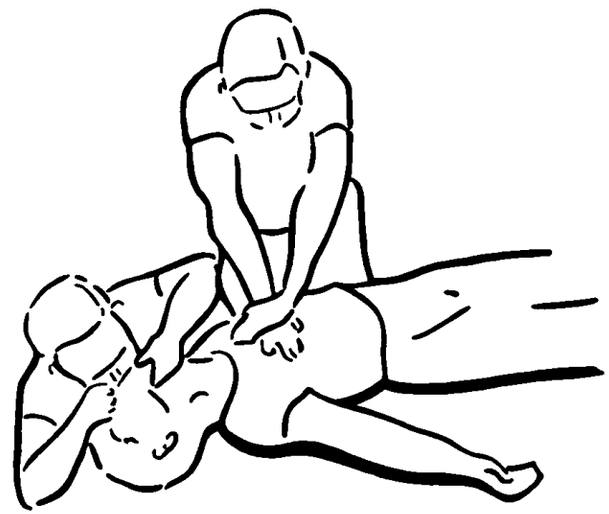
Cardiac arrest, or stopping of the heart beat, is most commonly found in situations involving – Electric Shock, Severe Respiratory Problems, Heart Disorders.

Establish ventilation first by administration of oxygen or mouth-to-mouth resuscitation. Listen for chest heart beat. Check for pulse at either side of the windpipe on the neck (carotid artery). If none is present, lift neck and extend head to open air passage.

Go into a kneeling position on either side of the patient. Then place the heel of one hand on the breastbone with the fingers pointing toward the patient's armpit. Now place the other hand directly on top of the first as shown by the illustration.

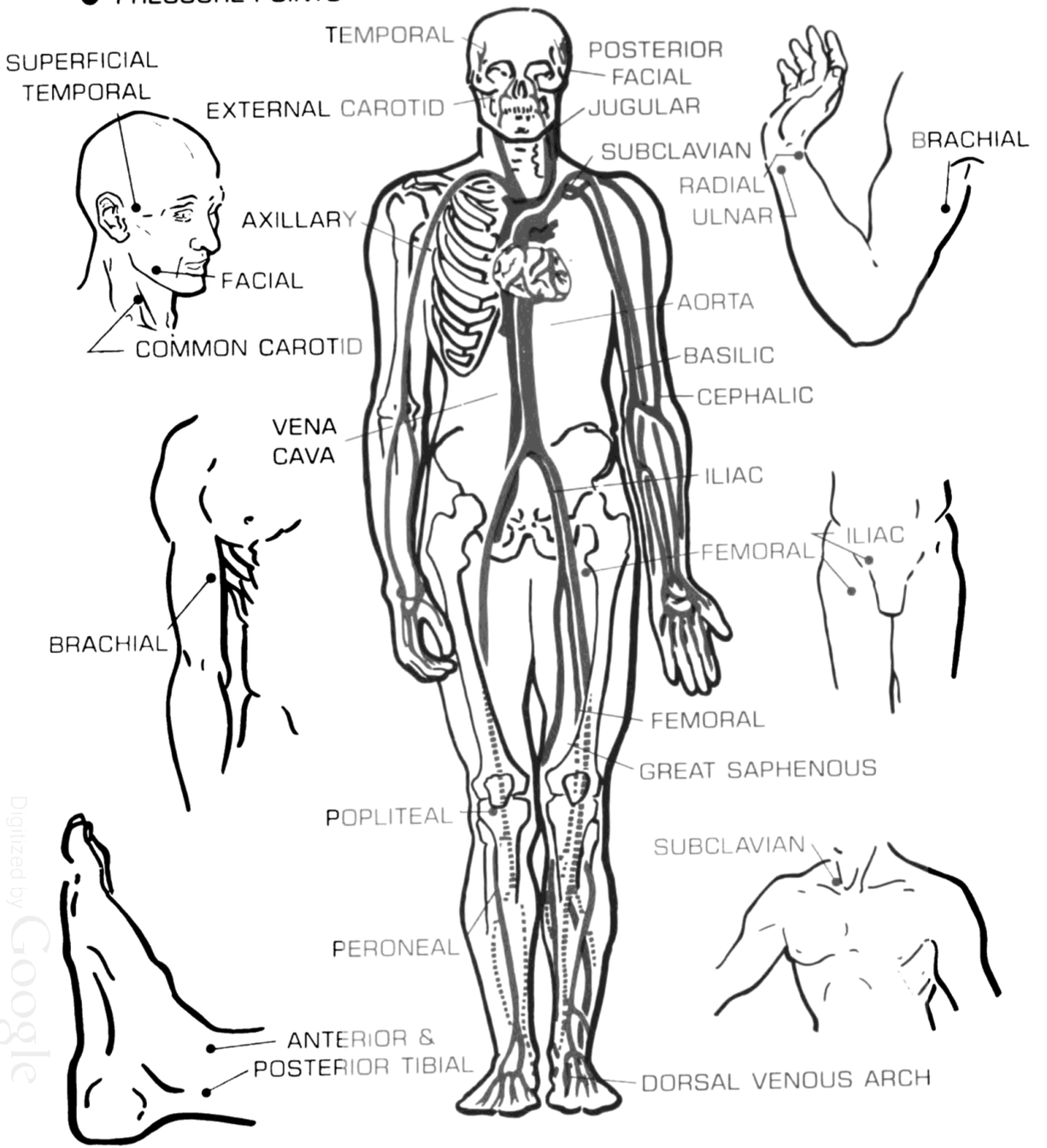
Press downward, using your body weight, compressing the chest approximately one inch. (Always use less pressure with children or the aged.) Release pressure immediately. Compress the chest and release approximately once every second.

Ventilation must be continuously maintained by mouth-to-mouth resuscitation or other means.



VENOUS & ARTERIAL SYSTEMS

● PRESSURE POINTS



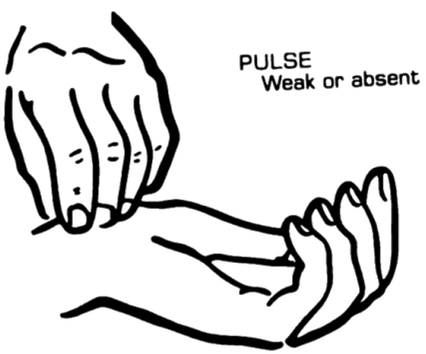
SYMPTOMS OF SHOCK

EYES
- Vacant
- Lackluster
- Pupils dilated

BREATHING
- Irregular

SKIN
- Pale
- Cold
- Moist

NAUSEA



UNDERWATER EMERGENCY PROCEDURES

ALWAYS

DIVER

Remain Calm

Communicate with Topside or Buddy

TOPSIDE

Send Down Standby Diver

Prepare for Emergency Recompression

Check Surfaced Diver for Injury

CAVE-IN, MUD ENTRAPMENT, FOULING

Diver Action

Move slowly and carefully.

Retrace steps to source of fouling and attempt to clear.

If entrapped in mud, attempt to tunnel out or increase buoyancy.

If using SCUBA, consider ditching equipment and free ascent.

Standby Diver Action

Check diver's gas supply.

Carefully remove obstructions.

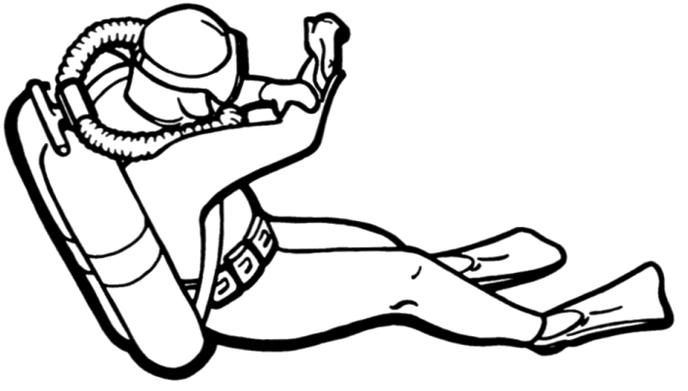
Bring down extra tunneling hose, if mud entrapment anticipated.

Assist diver during ascent.

Topside Action

Prepare for protracted surface recompression.

TRAUMATIC INJURY IN WATER



Diver Action

Reduce blood loss by application of pressure.

Standby Diver Action

Improvise tourniquet or pressure dressing.

Assist diver in making rapid ascent.

Be prepared to handle diver in shock.

Topside Action

Treat diver for shock and blood loss during recompression.

EXHAUSTED GAS SUPPLY, PARTED GAS HOSE

Diver Action

Use controlled blow-up, if possible.

If SCUBA, use buddy breathing and ascend.

If helmet diving, secure inlet and exhaust valves.

Standby Diver Action

If surface supplied, take down spare air line and tools. Connect replacement to diver goose-neck.

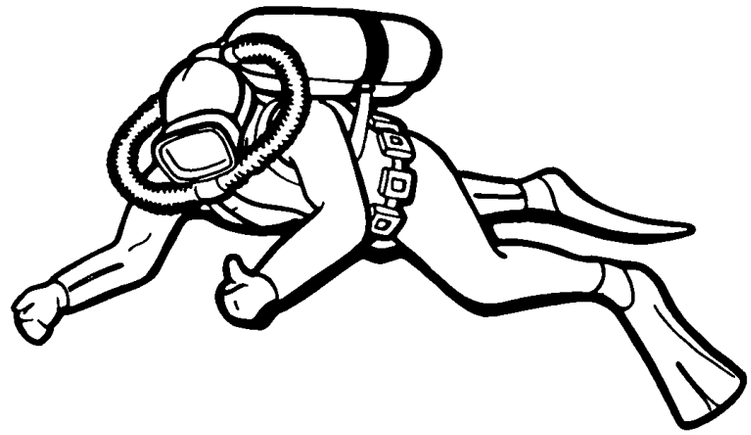
Ventilate helmet if diver unconscious.

Topside Action

Prepare to recompress for interrupted decompression.

Rig extra air line.

LOSS OF COMMUNICATIONS



Diver Action

In SCUBA:

a. Attempt to locate buddy.

b. Surface and report to dive supervisor.

Surface Supplied:

a. Use line signals.

b. Return to descending line and signal for ascent.

Standby Diver Action

Check diver for proper helmet ventilation.

Use hand signals to communicate.

Assist diver in ascent if necessary.

Topside Action

Try line signals.

BLOW-UP EMERGENCY ASCENT —OMITTED DECOMPRESSION

Diver Action

Exhale continuously.

If possible, exhaust enough gas to prevent suit rupture.

If SCUBA without assistance, jettison weights, make ascent by swimming.

Topside Action

Take in slack in lines and hoses quickly.

Quickly remove diver from water.

If no water stops are missed, decompress diver using Surface Decompression Tables.

If water stops have been omitted, take diver to depth (preferably in a recompression chamber) as appropriate for treatment Table 1, 1A or 5 (Table 1-30 and 1-31). If no ill effects appear, treat diver in accordance with treatment table selected. If symptoms of decompression sickness appear, treat diver in accordance with Recompression Chart on page 101.

UNCONSCIOUS DIVER

Standby Diver Action

Check diver for proper ventilation.

In SCUBA, use buddy breathing.

Assist diver in ascent.

Make rapid ascent.

At surface give mouth-to-mouth resuscitation.

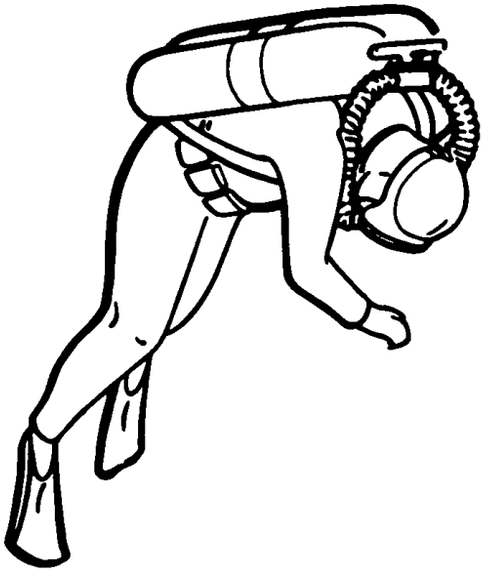
Topside Action

Change gas supply to diver.

Breakout Ambu-type resuscitator.

Recompress diver, give recompression treatment.

DROWNING



Diver Action

Prevent by:

A. Adequate training.

B. Good equipment condition.

C. Use of life jacket with SCUBA; life line when surface supplied.

D. Adequate prior planning.

E. Avoiding overexertion.

Standby Diver Action

Ventilate diver if possible.

Assist diver in making rapid ascent.

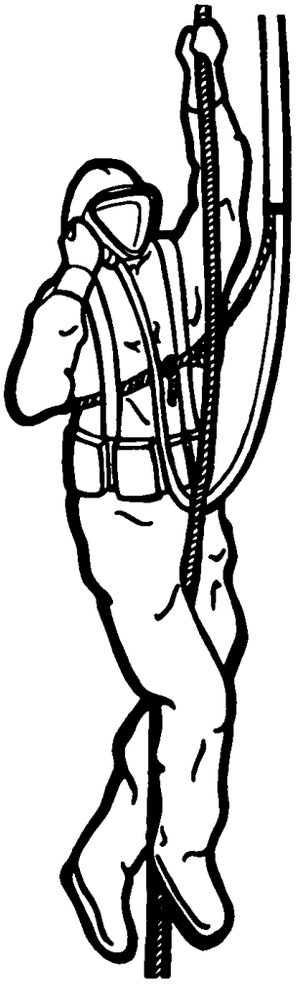
Give mouth-to-mouth resuscitation on surface.

Topside Action

Breakout mechanical resuscitator.

Recompress diver, provide forced ventilation during pressure treatment.

DECOMPRESSION ACCIDENT IN WATER



Diver Action

Advise standby or buddy diver of your condition.

Standby Diver Action

Assist diver in ascent.

Topside Action

Prepare for surface recompression.

Lower diver to depth of relief.

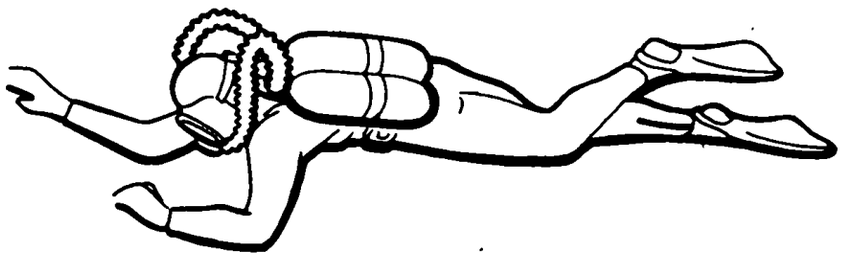
Provide stage or resting platform.

Use next longer and deeper decompression schedule or Table 2A.

Bring to surface decompression depth and then to surface for recompression.

If recompression chamber not available, request portable chamber or prepare to transport diver to suitable facilities.

OVER-EXERTION



Diver Action

If fatigued, anxious, weak, or panicky, stop work and rest.

If not recovering, ascend.

Standby Diver Action

Assist diver in ascent.

CONVULSION

Standby Diver Action

Avoid danger to self from wild actions of diver.

Attempt to prevent diver from injuring himself.

In SCUBA, keep diver's mouthpiece and mask in place.

Assist diver in making rapid ascent.

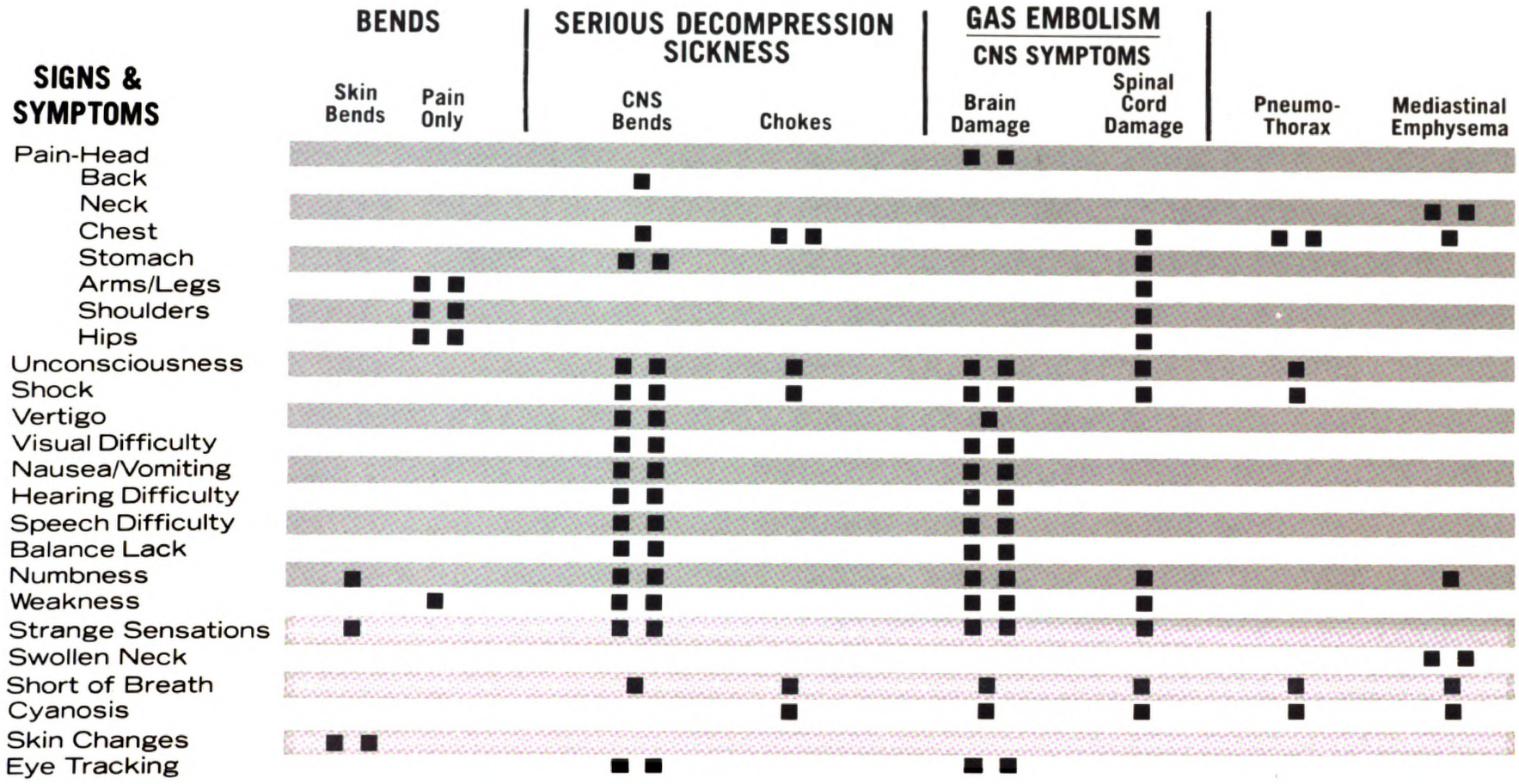
Topside Action

Change gas supply to leaner O_2 mix.

Recompress diver and treat for embolism unless probability of an embolism can be definitely ruled out.

If convulsions continue, restrain diver and use padded mouth bit.

DIAGNOSIS OF DECOMPRESSION SICKNESS



■ ■ Probable
■ Possible Cause

CONFIRMING INFORMATION

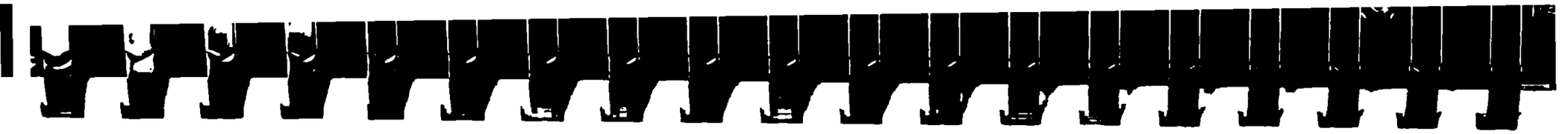
DIVING HISTORY

	Yes	No
Decompression Obligation?	☐	☐
Decompression Adequate?	☐	☐
Blow-up?	☐	☐
Breath-hold?	☐	☐
Non-pressure Cause?	☐	☐
Previous Exposure?	☐	☐

PATIENT EXAMINATION

	Yes	No
Does diver feel well?	☐	☐
Does diver look and act normal?	☐	☐
Does diver have normal strength?	☐	☐
Are diver's sensations normal?	☐	☐
Are diver's eyes normal?	☐	☐
Are diver's reflexes normal?	☐	☐

	Yes	No
Is diver's pulse rate normal?	☐	☐
Is diver's gait normal?	☐	☐
Is diver's hearing normal?	☐	☐
Is diver's coordination normal?	☐	☐
Is diver's balance normal?	☐	☐
Does the diver feel nauseous?	☐	☐



RULES FOR RECOMPRESSION TREATMENT

ALWAYS

1. Follow the Treatment Tables accurately.
2. Have qualified tender in chamber at all times during recompression.
3. Maintain the normal descent and ascent rates. Maintain rapid descent if serious symptoms are present.
4. Examine patient thoroughly at depth of relief or treatment depth.
5. Treat an unconscious patient for air embolism or serious decompression sickness unless the possibility of such a condition can be ruled out without question.
6. Consider the use of 80% helium-20% oxygen in cases of serious symptoms, recurrence of symptoms, or when patient has difficulty breathing.
7. Use oxygen if available. Ensure that patient can tolerate oxygen.
8. Use Oxygen Treatment Tables (5, 5A, 6, 6A) under the supervision of a Medical Officer, either directly or by telephone. A qualified medical assistant must accompany the patient in the chamber during treatment.
9. Be alert for oxygen poisoning if oxygen is used.
10. Know what to do in the event of oxygen convulsion.
11. Maintain oxygen usage within the time and depth limitations.
12. Take all precautions against fire if oxygen is used.
13. Provide water and sand buckets.
14. Use fire retardant paint and materials in the chamber.
15. Ventilate the chamber according to specified rates and gas mixtures.
16. Check patient's condition before and after coming to each stop and during long stops.
17. Observe patient for at least 6 hours after treatment for recurrence of symptoms.
18. Maintain accurate timekeeping and recording.
19. Assure proper decompression of all personnel entering the chamber.
20. Ensure that the chamber and its auxiliary equipment is in operational condition at all times.
21. Maintain a well stocked medical kit at hand.
22. Ensure that all personnel are trained in operation of equipment and are able to do any job required in treatment.

RULES FOR RECOMPRESSION TREATMENT

NEVER

1. Permit any shortening or other alteration to the tables **except** under the direction of a trained Diving Medical Officer.
2. Exceed descent rate tolerated by the patient.
3. Delay recompression for physical examination or first aid. Do this during recompression.
4. Let patient sleep between depth changes or for more than one hour at any one stop.
5. Continue ascent if patient's condition worsens.
6. Wait for a mechanical resusitator. Use mouth-to-mouth immediately if breathing ceases.
7. Break rhythm during artificial resperation.
8. Permit the use of oxygen below 60 feet.
9. Use oil on any oxygen fitting or piece of equipment.
10. Fail to report symptoms early (diver).
11. Fail to treat doubtful cases.
12. Allow gas supply tanks to be depleated or reach low capacity.
13. Allow damage to door seals and dogs. Use minimum force in "dogging down."
14. Leave doors dogged after pressurization.
15. Allow open flames, matches, cigarette lighters or pipes to be carried into the chamber.
16. Permit electrical appliances to be used during oxygen-breathing or when chamber atmosphere is compressed air.

NOTES

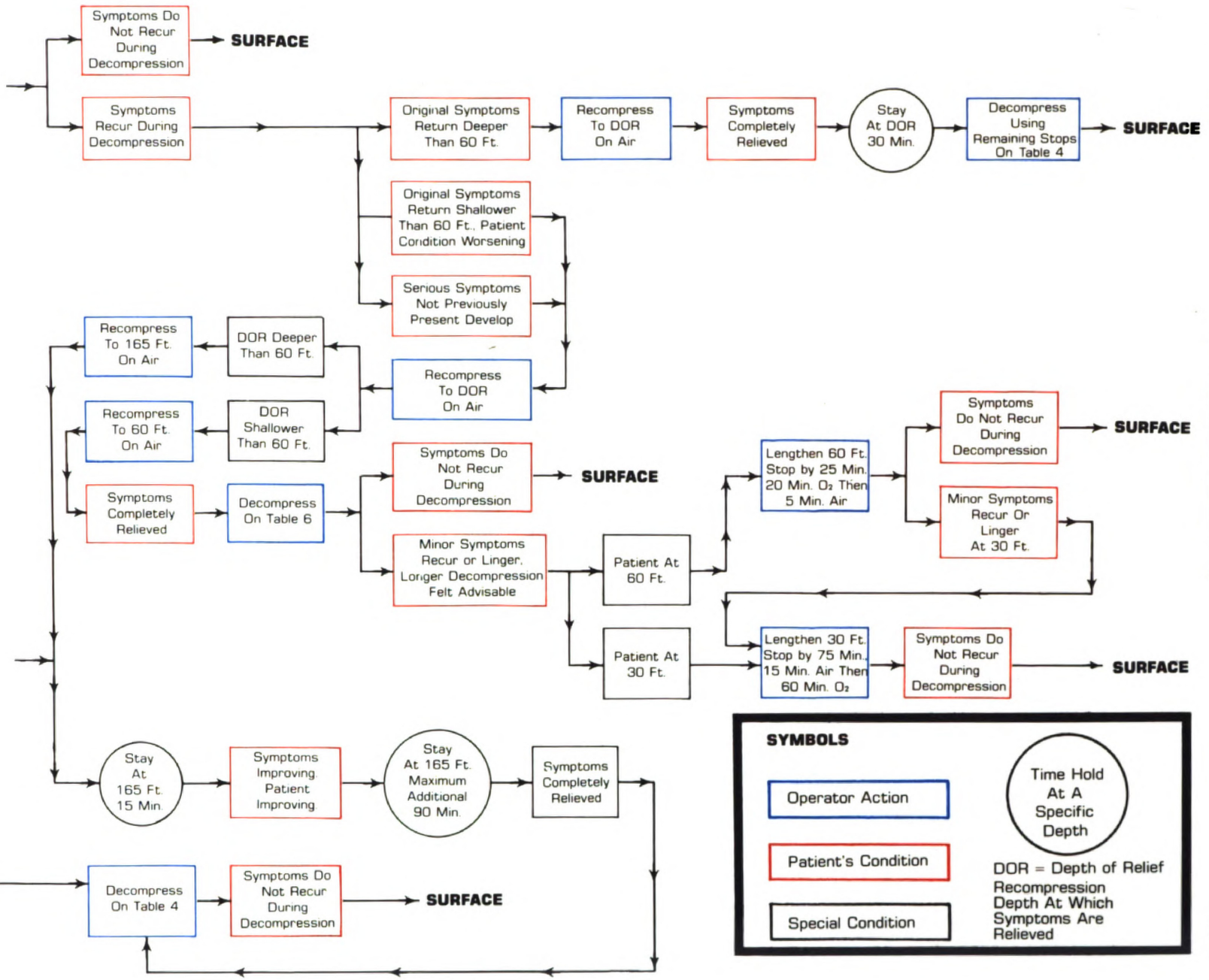
RECOMPRESSION TREATMENT CHART

STEP 1

Stay **at 165 Ft.** for an additional **90 Min.**

STEP 2

If all **symptoms** are relieved **within** 120 Min. at 165 Ft., Decompress on Table 4 and Follow Arrows.



RECOMPRESSION PROCEDURE FOR RECURRENCE OF SYMPTOMS FOLLOWING TREATMENT

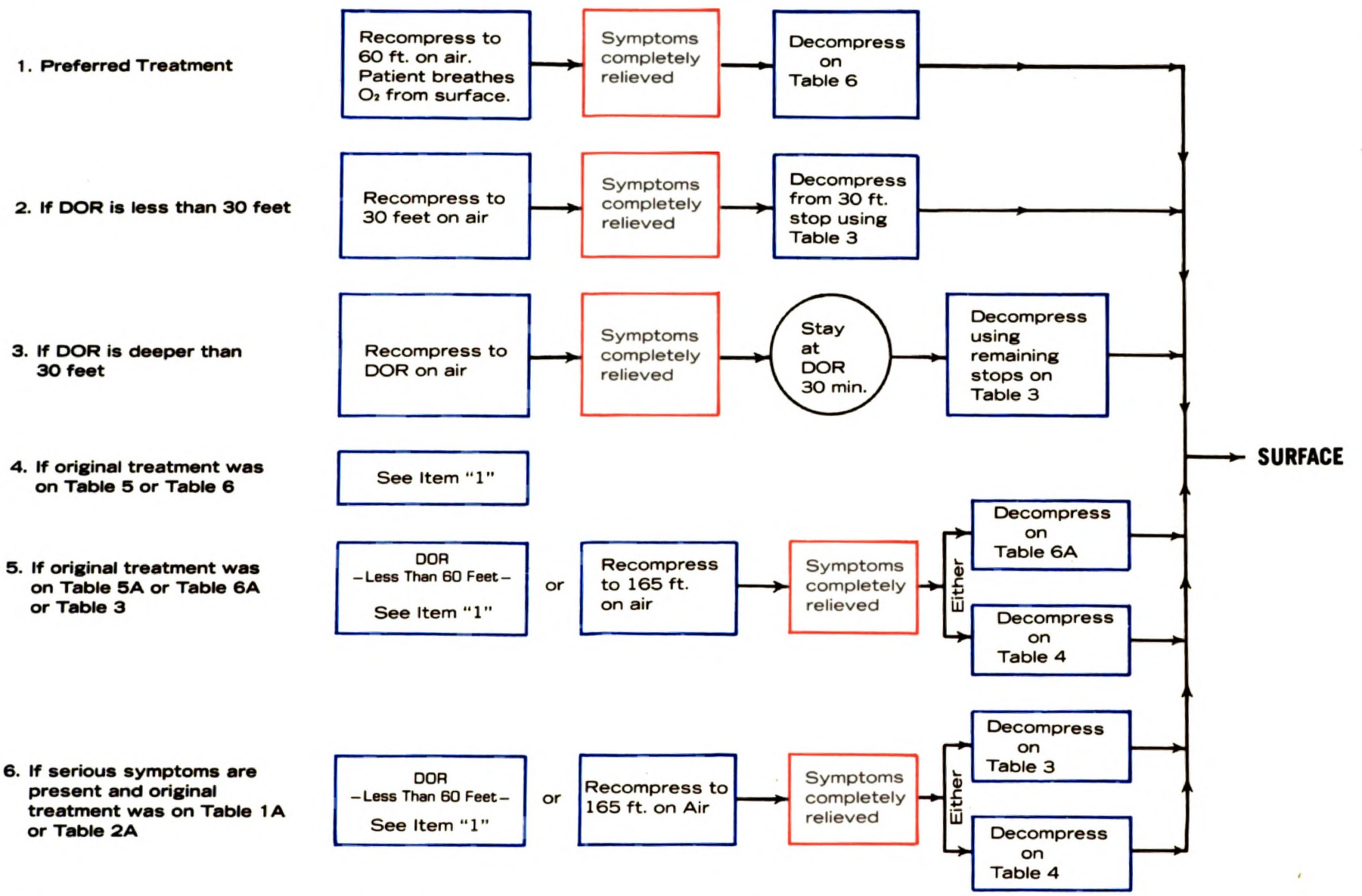


TABLE 1-30/TREATMENT OF DECOMPRESSION SICKNESS AND GAS EMBOLISM

(FORMERLY TABLE 1-21, 1963 DIVING MANUAL)

GENERAL NOTES:

Rate of descent is 25 ft./min.

Rate of ascent is 1 minute between stops.

The time at 165 feet (100 feet for TABLE 1A) is total bottom time and includes the time from the surface.

TABLE 1A and TABLE 2A-SPECIFIC NOTES

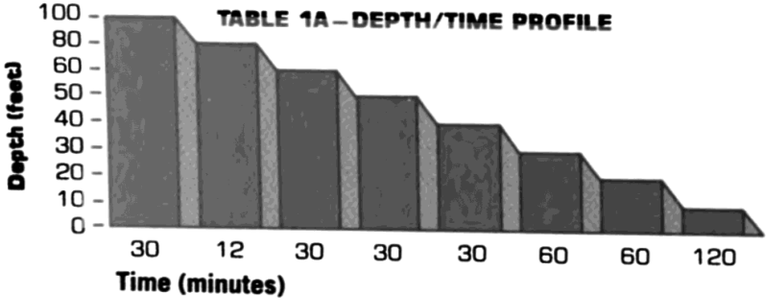
(To be used for treatment of bends only when oxygen cannot be used.)

Use TABLE 1A if pain is relieved at a depth LESS THAN 66 feet.

Use TABLE 2A if pain is relieved at a depth GREATER THAN 66 feet.

TABLE 1A

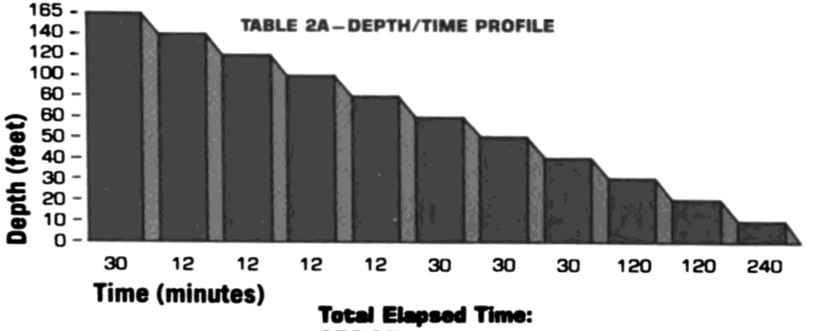
Depth (feet)	Time (minutes)	Breathing Media	Total Elapsed Time (minutes)
100	30	Air	30
80	12	Air	43
60	30	Air	74
50	30	Air	105
40	30	Air	136
30	60	Air	197
20	60	Air	258
10	120	Air	379
0	1	Air	380



Total Elapsed Time: 380 Minutes

TABLE 2A

Depth (feet)	Time (minutes)	Breathing Media	Total Elapsed Time (minutes)
165	30	Air	30
140	12	Air	43
120	12	Air	56
100	12	Air	69
80	12	Air	82
60	30	Air	113
50	30	Air	144
40	30	Air	175
30	120	Air	296
20	120	Air	417
10	240	Air	658
0	1	Air	659



Total Elapsed Time: 659 Minutes

TABLE 3 and TABLE 4 SPECIFIC NOTES

(To be used for treatment of serious symptoms when oxygen cannot be used.)

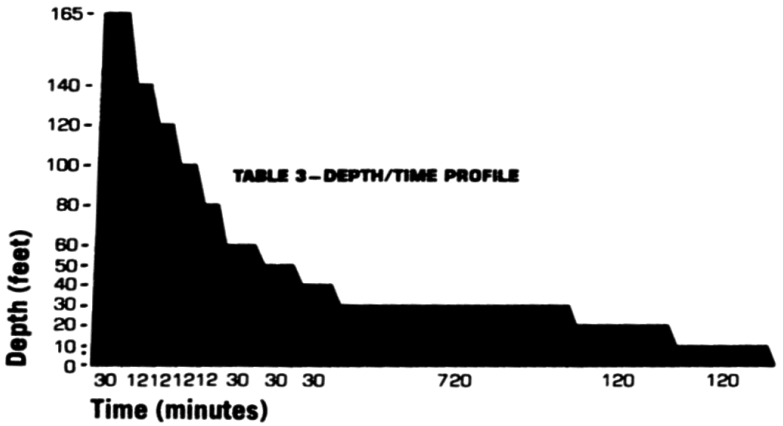
Total time will vary depending on the amount of time patient spends at the 165 foot stop while being examined by the medical attendant.

Use TABLE 3 if symptoms ARE relieved within 30 minutes at 165 feet.

Use TABLE 4 if symptoms ARE NOT relieved within 30 minutes at 165 feet.

TABLE 3

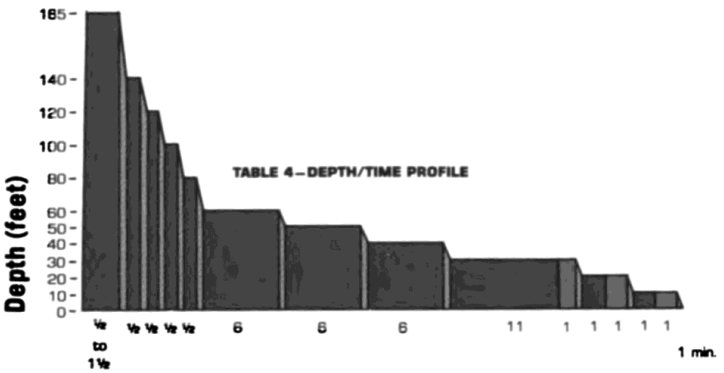
Depth Feet	Time	Breathing Media	Total Elapsed Time (hrs:min)
165	30 min.	Air	0:30
140	12 min.	Air	0:43
120	12 min.	Air	0:56
100	12 min.	Air	1:09
80	12 min.	Air	1:22
60	30 min.	Oxygen (or air)	1:53
50	30 min.	Oxygen (or air)	2:24
40	30 min.	Oxygen (or air)	2:55
30	12 hr.	Air	14:56
20	2 hr.	Air	16:57
10	2 hr.	Air	18:58
0	1 min.	Air	18:59



Total Elapsed Time:
18 Hours 59 Minutes

TABLE 4

Depth (feet)	Time	Breathing Media	Total Elapsed Time (hrs:min)
165	½ to 1½ hr.	Air	1:30
140	½ hr.	Air	2:01
120	½ hr.	Air	2:32
100	½ hr.	Air	3:03
80	½ hr.	Air	3:34
60	6 hr.	Air	9:35
50	6 hr.	Air	15:36
40	6 hr.	Air	21:37
30	11 hr.	Air	32:38
30	1 hr.	Oxygen (or Air)	33:38
20	1 hr.	Air	34:39
20	1 hr.	Oxygen (or Air)	35:39
10	1 hr.	Air	36:40
10	1 hr.	Oxygen (or Air)	37:40
0	1 min.	Oxygen	37:41



Total Elapsed Time:
37 Hours 41 Minutes

TABLE 1-31/MINIMAL RECOMPRESSION, OXYGEN BREATHING METHOD FOR TREATMENT OF DECOMPRESSION SICKNESS AND AIR EMBOLISM

(FORMERLY TABLE 1-21, 1963 DIVING MANUAL)

GENERAL NOTES

I. The rate of ascent is 1 ft./min.

II. Do not compensate for slowing the rate of ascent by subsequent acceleration.

III. Do compensate if the 1 ft./min. rate of ascent is exceeded. If necessary, halt the ascent and hold depth while ventilating the chamber.

IV. Tender breathes air throughout. If treatment is a repetitive dive for the tender or tables 6 or 6A are lengthened, tender should breathe oxygen during the last 30 minutes of ascent to the surface.

V. If oxygen breathing must be interrupted, allow 15 minutes after the reaction has entirely subsided and resume schedule at the point of interruption.

TABLE 5 and TABLE 6—SPECIFIC NOTES

(To be used if depth of relief is 60 feet.)

A. Rate of descent is 25 ft./min.

B. The time at 60 feet begins on arrival at 60 feet.

C. Use TABLE 5 if symptoms ARE relieved within 10 minutes at 60 feet.

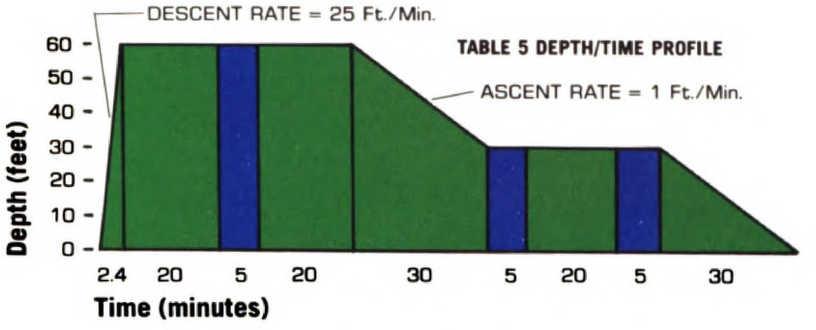
D. Use TABLE 6 if symptoms ARE NOT relieved within 10 minutes at 60 feet.

E. The patient should be on oxygen from the surface.

F. If oxygen breathing must be interrupted at 60 feet, upon arrival at the 30 foot stop, switch to the schedule of TABLE 6.

TABLE 5

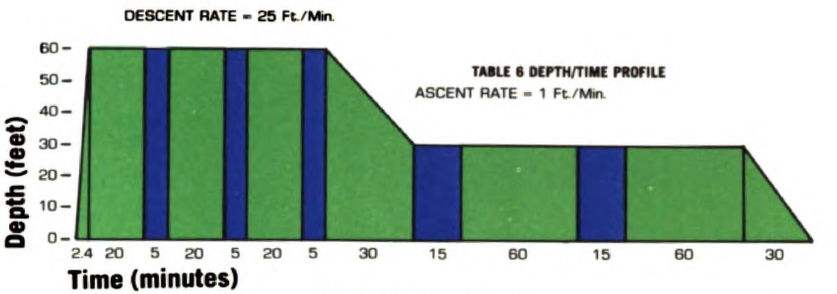
Depth (feet)	Time (minutes)	Breathing Media	Total Elapsed Time (minutes)
60	20	Oxygen	20
60	5	Air	25
60	20	Oxygen	45
60 to 30	30	Oxygen	75
30	5	Air	80
30	20	Oxygen	100
30	5	Air	105
30 to 0	30	Oxygen	135



Total Elapsed Time: 135 Minutes

TABLE 6

Depth (feet)	Time (minutes)	Breathing Media	Total Elapsed Time (minutes)
60	20	Oxygen	20
60	5	Air	25
60	20	Oxygen	45
60	5	Air	50
60	20	Oxygen	70
60	5	Air	75
60 to 30	30	Oxygen	105
30	15	Air	120
30	60	Oxygen	180
30	15	Air	195
30	60	Oxygen	255
30 to 0	30	Oxygen	285



Total Elapsed Time: 285 Minutes

TABLE 5A and TABLE 6A—SPECIFIC NOTES

A. Rate of descent as fast as possible.

B. The time at 165 feet is total bottom time and includes the time from the surface.

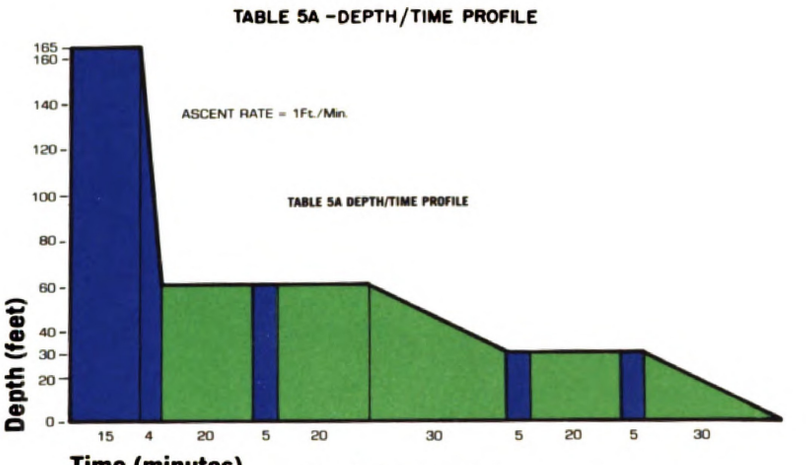
C. Use TABLE 5A if all symptoms ARE relieved within 15 minutes at 165 feet.

D. Use TABLE 6A if symptoms moderate to a major extent within 30 minutes at 165 feet.

E. Total time will vary depending on the amount of time patient spends at 165 foot stop while being examined by the medical attendant.

TABLE 5A

Depth (feet)	Time (minutes)	Breathing Media	Total Elapsed Time (minutes)
165	15	Air	15
165 to 60	4	Air	19
60	20	Oxygen	39
60	5	Air	44
60	20	Oxygen	64
60 to 30	30	Oxygen	94
30	5	Air	99
30	20	Oxygen	119
30	5	Air	124
30 to 0	30	Oxygen	154

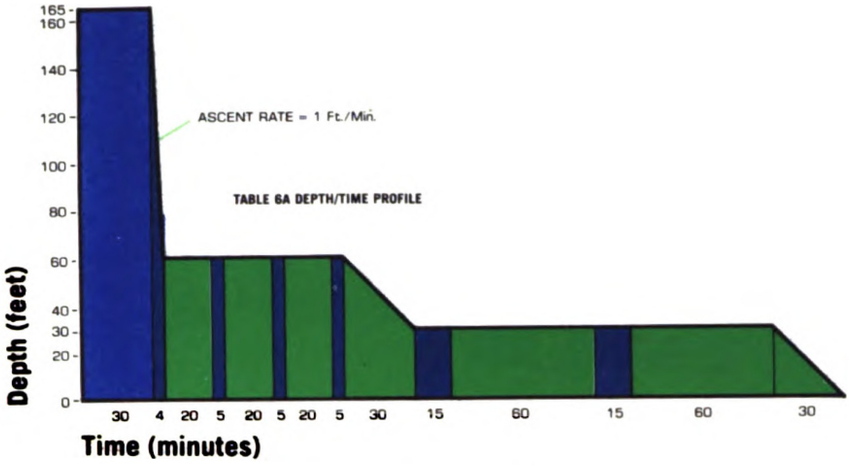


Total Elapsed Time: 154 Minutes

TABLE 6A

Depth (feet)	Time (minutes)	Breathing Media	Total Elapsed Time (minutes)
165	30	Air	30
165 to 60	4	Air	34
60	20	Oxygen	54
60	5	Air	50
60	20	Oxygen	79
60	5	Air	84
60	20	Oxygen	104
60	5	Air	109
60 to 30	30	Oxygen	139
30	15	Air	154
30	60	Oxygen	214
30	15	Air	229
30	60	Oxygen	289
30 to 0	30	Oxygen	319

TIME PROFILE



Total Elapsed Time:
319 Minutes

NOTES

SECTION 5—MIXED GAS DIVING OPERATIONS

INTRODUCTION

Significant advances have been made in mixed-gas diving during the past few years. This section of the Handbook introduces three new types of equipment which will soon be entering fleet service in addition to current apparatus. The techniques and equipment used in mixed-gas diving are significantly more complex than those used in air diving. Special attention must be paid to the Safety Rules section and checkout procedures to avoid accidents.

The selector chart for Gas and Absorbent Usage provides a simplified technique for determining the useful underwater life of breathing apparatus.

A MEDICAL OFFICER AND RECOMPRESSION CHAMBER ARE REQUIRED FOR ALL SURFACE-SUPPLIED MIXED-GAS DIVING

GENERAL SAFETY RULES FOR MIXED GAS DIVING

DEEP-SEA RECIRCULATING GEAR

ALWAYS

1. Be familiar with the General Safety Rules for Air and Oxygen Diving.
2. Maintain 100 psi gas supply pressure over bottom pressure, except during oxygen decompression when the pressure may be reduced to 50 psi over bottom pressure.
3. Keep exertion or exercise to a minimum while breathing O_2 at the 50 and 40 foot stops.
4. Ventilate the hose to insure that the diver is actually breathing an HeO_2 mixture prior to putting diver down. The distinctive change in tone of the diver's voice should be heard.
5. Be alert to recognize symptoms of O_2 poisoning while at the oxygen stop. At first symptom, diver and topside support should take immediate corrective action.

NEVER

1. Commence diving operations unless there is sufficient gas mixture available and it has been checked to determine if it is of proper composition.
2. Hesitate to bypass the venturi supply by periodically opening control valve while on the bottom if the diver develops symptoms of inadequate ventilation. Upon reaching surface, cause of inadequate ventilation should be located.

NOTES

SELF-CONTAINED DIVING (SEMI-CLOSED-CIRCUIT SCUBA)

ALWAYS –

1. Charge apparatus with a standard mixture.
2. Use fresh absorbent in the canister.
3. Set injector to proper flow for anticipated work and water conditions.
4. Be alert for failure of exhaust valve to bubble.

NEVER –

1. Exceed depth limitation for gas mixture used.

THE TEN HELIOX RULES FOR HeO_2 SUPPLY— O_2 TOXICITY PROBLEMS DURING ASCENT

LOSS OF HeO_2 SUPPLY

DEEPER THAN 50 FT.

1. Shift to air, come all the way out in accordance with Emergency Air Table (Table 1-25). No surface decompression.

LOSS OF O_2 SUPPLY

LOSS AT 50-FOOT STOP

1. Shift to air (or HeO_2). Complete stop in accordance with Emergency Table 1-25 (or Table No. 1-24). Can surface decompress after 30 ft. stop. O_2 time is good time.

LOSS AT 40-FOOT STOP

1. **Not Within Surface Decompression or Emergency Surface Decompression Limits:** (Same treatment as above)
2. **Within Emergency Surface Decompression Limits:** Surface decompress diver. Double missed time of required water stop for surface decompression and add to chamber stop.
3. **Within Normal Surface Decompression Limits:** Surface decompress normally.

O_2 TOXICITY SYMPTOMS

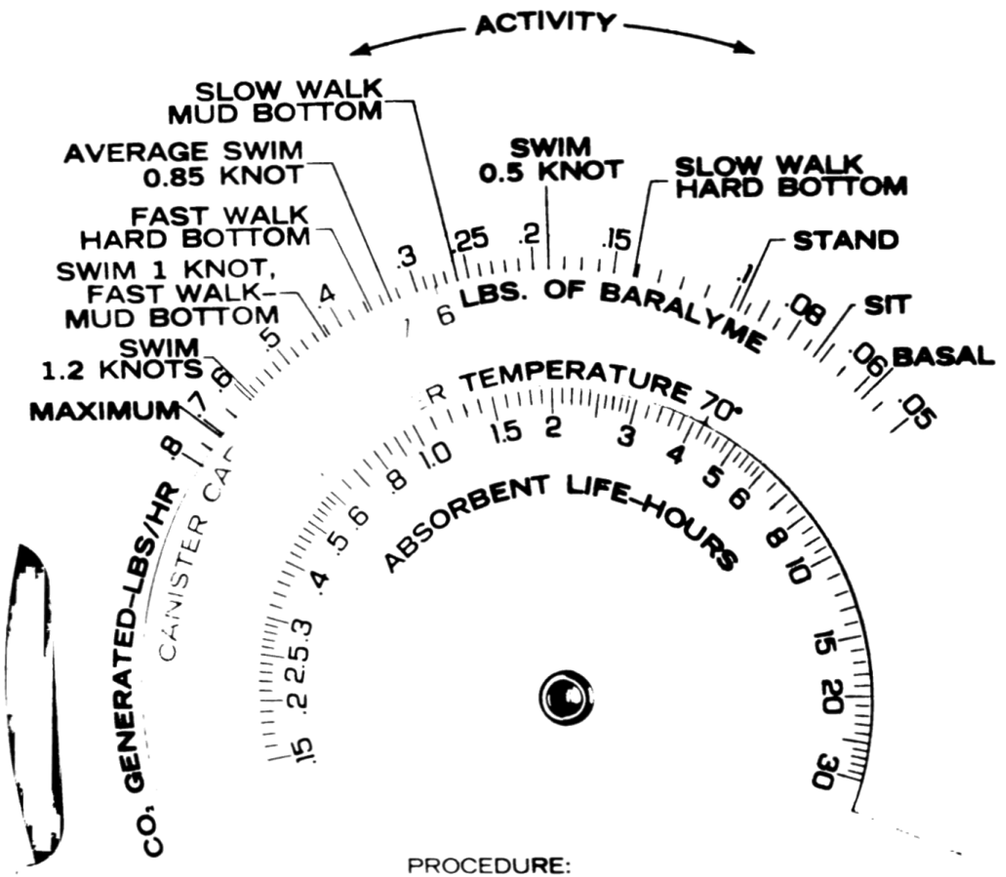
SYMPTOMS AT 50-FOOT STOP

1. Ascend to 40 ft. stop. Shift to air (or HeO_2). Can surface decompress after 30 ft. stop. Disregard missed time at 50 ft.

SYMPTOMS AT 40-FOOT STOP:

1. **Not Within Surface Decompression or Emergency Surface Decompression Limits:** Ascend to 30 ft. stop. Shift to air (or HeO_2). Can surface decompress after 30 ft. stop. Disregard missed time at 40 ft.
2. **Within Emergency Surface Decompression Limits:** Surface decompress diver. Double missed time of required water stop for surface decompression and add to chamber stop.
3. **Within Normal Surface Decompression Limits:** Surface decompress normally.
4. **Symptoms During Chamber Stop:** Remove mask. Complete decompression in accordance with Emergency Air Table (Table No. 1-25). O_2 time is good time.

CO_2 ABSORBENT USAGE

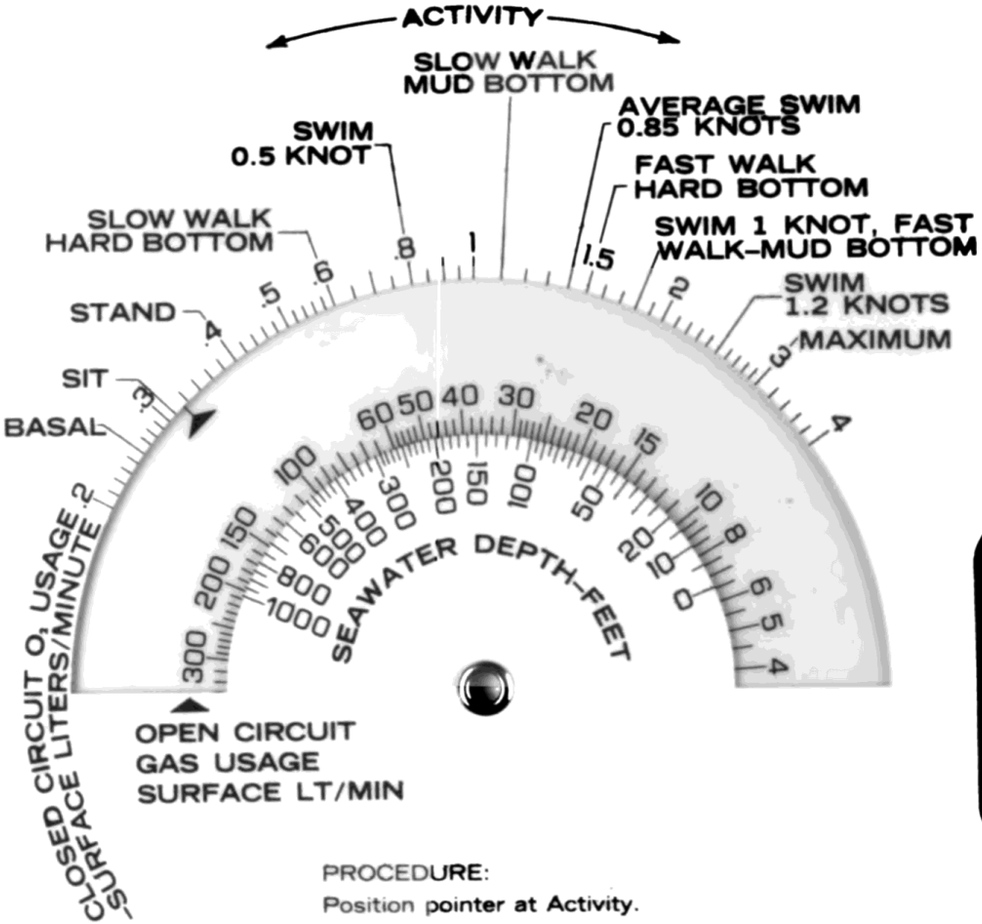


PROCEDURE:

Position **Canister Capacity** opposite Activity or CO_2 Rate.

Read **Absorbent Life** (Hours) opposite **Canister** Temperature.

GAS USAGE



PROCEDURE:

Position pointer at Activity.

Read Closed Circuit Use inside the pointer.

Read Open Circuit Use opposite Seawater Depth.

CANISTER CAPACITY IS BASED ON POUNDS OF PACKED BARALYME WEIGHT.
CO_2 ABSORBENT CAPACITY IS THE SAME FOR EQUAL PACKED VOLUMES (NOT WEIGHTS) OF SODASORB OR LITHIUM HYDROXIDE.

CANISTER CAPACITIES OF STANDARD CANISTERS:

EQUIPMENT:	DEEP SEA RECIRCULATING	O_2 CLOSED CIRCUIT	MKVI	MKVIII	MKIX	MKX	MKXI
CAPACITY –POUNDS	6	6	6	8	8	7	10

STANDARD SURFACE LITERS/MINUTE FOR SEMI-CLOSED CIRCUIT EQUIPMENT:

GAS MIX	SWIMMING DIVE	NON-SWIMMING DIVE
60% O_2, 40% N_2	8	4
40% O_2, 60% N_2	12	8
32.5% O_2, 67.5% N_2	21	12
32% O_2, 68% He	18.5 (12.5*)	–
40% O_2, 60% He	11 (8*)	–

*AIR CALIBRATED FLOW METER READING

CAPACITY OF STORAGE UNITS

EQUIPMENT	RATED PRESSURE PSIG	WATER VOLUME CUBIC INCHES	GAS CAPACITY SURFACE VOLUME FEET³	GAS CAPACITY SURFACE VOLUME LITERS	RESERVE PRESSURE PSIG	RECOMMENDED MINIMUM PRESSURE PSIG	GAS CONTENT
CLOSED CIRCUIT O_2	2000	152	12.7	360	500	500	O_2
OPEN CIRCUIT-STEEL "72"	2150	835	71.2	2090	300	430	AIR
OPEN CIRCUIT-STEEL "53"	2150	620	52.8	1495	300	430	AIR
OPEN CIRCUIT-ALUMINUM	3000	725	84	2380	500	600	AIR
MK VI SEMI-CLOSED	3000	725	77	2380	None	600	He-O_2
MK VIII SEMI-CLOSED	3000	725	77	2380	None	600	He-O_2
MK X CLOSED CIRCUIT-O_2	3000	150	18	510	None	600	O_2
MK X CLOSED CIRCUIT-DILUENT	3000	150	16	453	None	600	He
MK XI SEMI-CLOSED (2 CYLINDERS)	3000	330	35	991	2700	2700	He-O_2
270 FT.³ ICC CYLINDER	2200	3050	266	7533	None	440	AIR
220 FT.³ ICC CYLINDER	2200	2525	220	6230	None	440	AIR
MIL-F-22606B-10 FT.³	3000	17280	1990	56360	None	600	AIR

All data are based on the capacity of a single cylinder or tank, (except as noted for the MK XI) at 70° with gas content as listed.

CAPACITY FACTORS:	AIR N_2–O_2	He	He–O_2	O_2
2000 to 2200 psi	1.00	0.94	0.94	1.06
3000 psi	0.97	0.91	0.91	1.04

TEMPERATURE FACTORS:

40°F	70°F	100°F
1.07	1.00	0.94

CALCULATION PROCEDURE FOR OPERATIONAL GAS REQUIREMENTS:

$$\text{STORAGE VOLUME REQUIRED} = \left\{ \frac{\text{GAS USE RATE* SURFACE LITERS/MINUTE} \times \text{MINUTES OF DIVE} \times \text{RATED SURFACE PRESSURE}}{\text{MEASURED STORAGE PRESSURE} - \text{RECOMMENDED MINIMUM PRESSURE}} \right\} \times \text{TEMPERATURE FACTOR FOR TEMPERATURE AT WHICH GAS WILL BE USED}$$

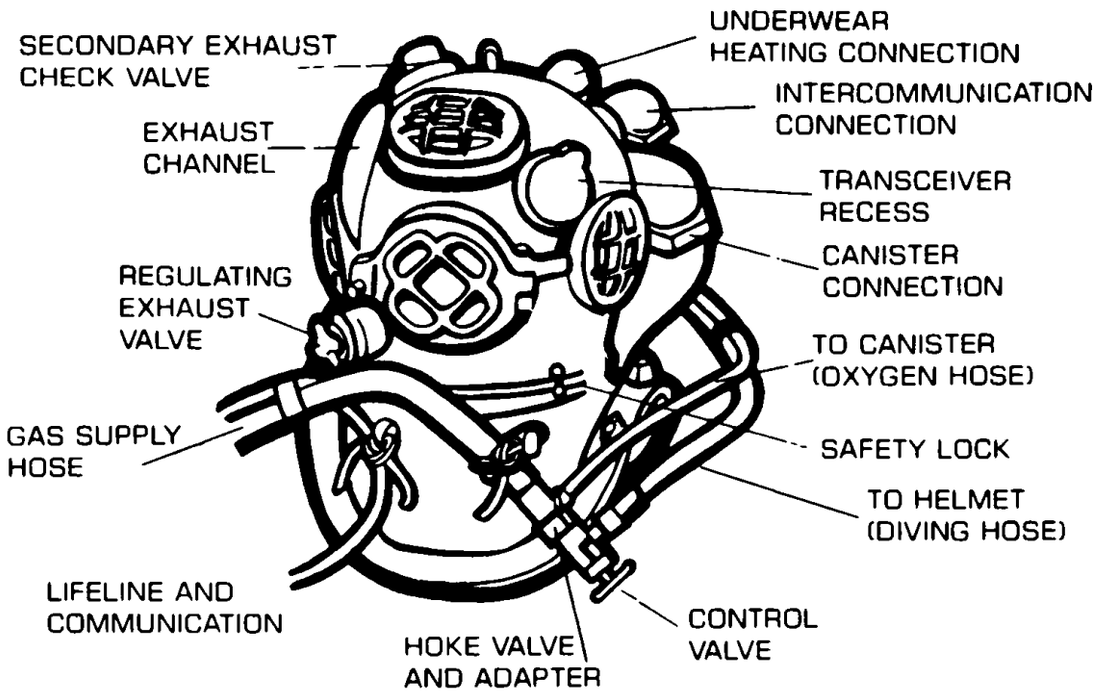
Add up required storage volumes for each stage of the dive to get total gas storage required.

$$\text{STORAGE VOLUME AVAILABLE} = \frac{\text{LISTED SURFACE LITERS/TANK AT RATED PRESSURE} \times \text{NUMBER OF TANKS} \times \text{TEMP. FACTOR FOR TEMP. AT WHICH STORAGE PRESSURE WAS MEASURED} \times \text{CAPACITY FACTOR FOR GAS USED}}{\text{CAPACITY FACTOR FOR LISTED GAS CONTENT}}$$

Available storage volume must equal or exceed required storage volume.

*Gas use in surface liters per minute is taken from opposite side.

DEEP SEA RECIRCULATING GEAR



PREDIVE PROCEDURES

(To be conducted by the Diving Supervisor)

1. ☐ Break out and check all equipment to be used by the diver:

MINIMUM EQUIPMENT

- ☐ Diving dress
- ☐ Weighted belt
- ☐ Weighted shoes
- ☐ Underwear
- ☐ Cuffs/Gloves
- ☐ Intercommunication cable and lifeline
- ☐ Gas supply hose
- ☐ Knife
- ☐ Helmet cushion
- ☐ Helium-oxygen helmet and breastplate
- ☐ Pneumofathometer—a device which allows accurate determination of the diver's depth. It consists of an oxygen hose connected to an air supply at the surface and to the diver's breastplate. Air is bubbled out of the hose at the diver and the air pressure is read on a gage on the surface. This pressure, read in feet of seawater, plus 5 feet, is equal to the diver's depth.

OPTIONAL EQUIPMENT

- ☐ Overalls
- ☐ Light
- ☐ Slate
- ☐ Tools/Toolbag
- ☐ Other

2. ☐ Check the helium-oxygen supply.
   - ☐ Primary supply; correct mixture?
   - ☐ Secondary supply.

3. ☐ Check all piping connections.
4. ☐ Close the control valve and Hoke valve. Pressurize the He-O_2 supply hose. Check for leaks.
5. ☐ Check the non-return valve.
6. ☐ Take depth soundings.
7. ☐ Check the descending line, decompression stage and stage lines.
8. ☐ Check the recompression chamber.
9. ☐ Dress the diver as per recommended procedures.
10. ☐ Check the CO_2 absorbent canister to ensure that it is properly filled* with GRANULAR BARALYME.

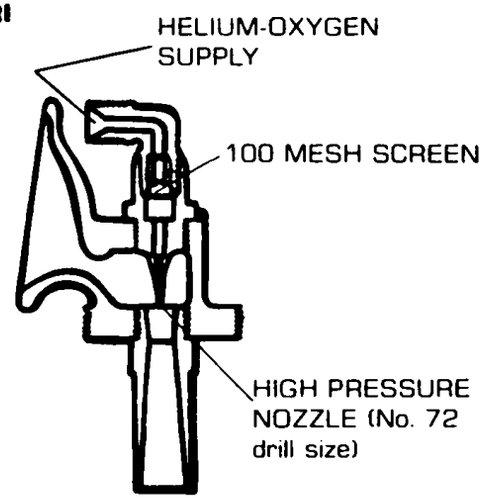
*Canister Packing Procedure:

a. Use only fresh Granular Baralyme.
b. Wipe off Baralyme container before opening.
c. Fill canister from both sides. Pour directly from container. DO NOT USE THE LAST TWO INCHES OF BARALYME IN THE CONTAINER.
d. Fill the left side level with the screen rim.
e. Fill the right (venturi) side to within 3 inches of the canister rim.
f. Tap the canister gently on the deck.

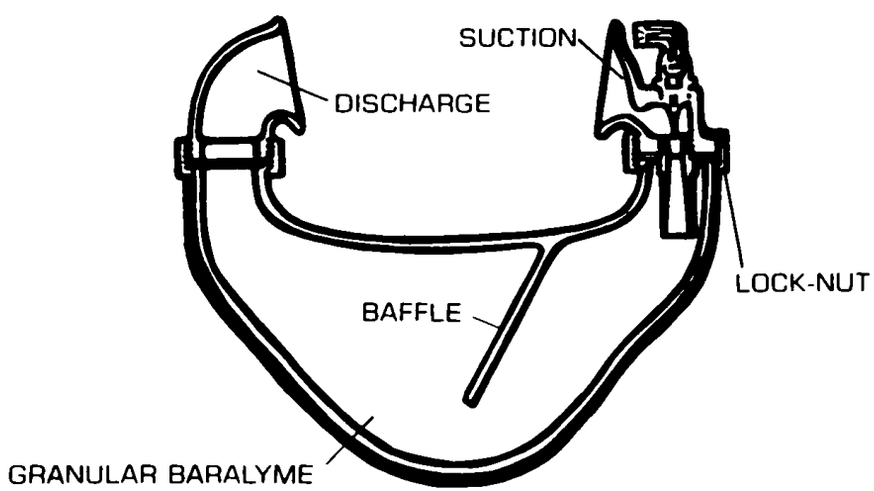
DO NOT SHAKE
OR POUND CANISTER.

g. A properly filled canister will hold at least 6 pounds of Baralyme.

VENTURI



CANISTER



PREDIVE INSPECTION

(To be conducted by the Dive Supervisor)

1. ☐ Verify predive procedures.
2. ☐ Have diver ventilate his helmet to ensure that he is breathing He-O_2. (Note a distinct change in voice.)
3. ☐ Check the safety lock on the helmet.
4. ☐ Check the communications.
5. ☐ Review mission and dive profile.
6. ☐ Check diver's tender.
7. ☐ Place diver on stage and hoist him slowly into the water.

SURFACE CHECKOUT

(To be conducted by the diver upon entering the water)

1. ☐ Check that the dress is air tight.
2. ☐ Check the communications.
   REPORT ANY MALFUNCTIONS
   OR DEFICIENCIES
   TO THE DIVE SUPERVISOR
3. ☐ Signal the tender when prepared to descend.

POSTDIVE PROCEDURES

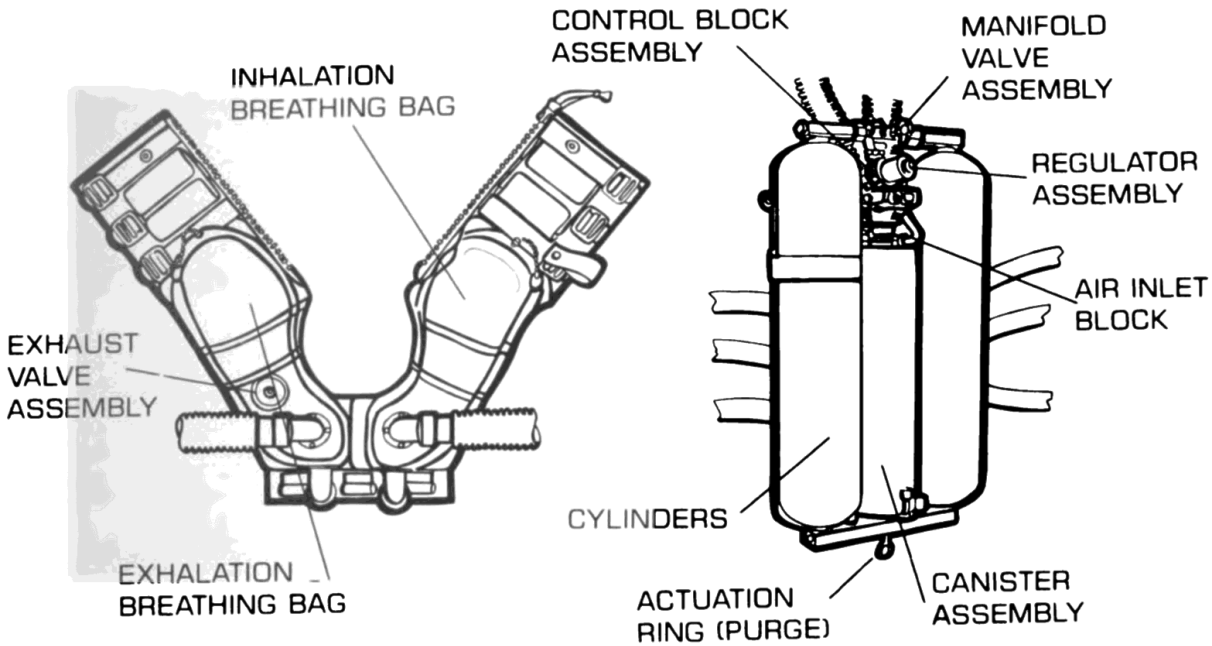
1. ☐ As the diver leaves the water, the Dive Supervisor is to check him for any signs of sickness or injury that may have resulted from the dive.
2. ☐ Check all diving gear for damage. Clean and dry all diving gear and stow in a cool, dry compartment. Check all gear periodically to ensure that it is always ready for immediate use.

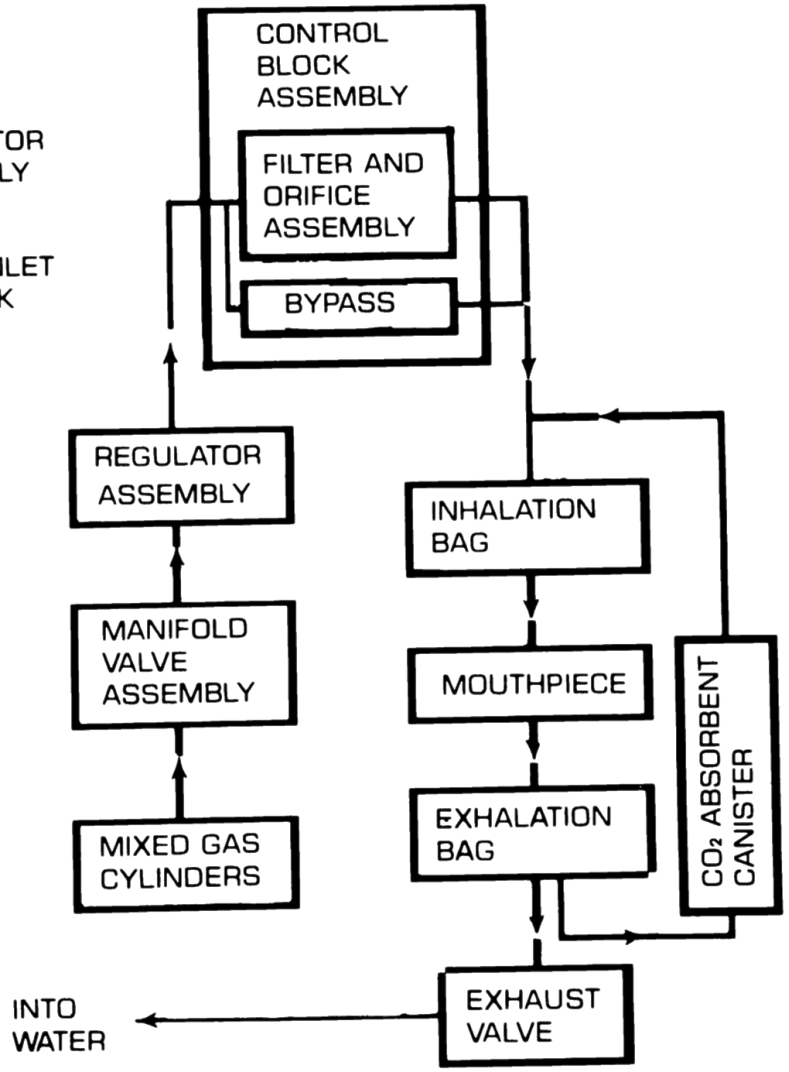
UNDERWATER PROCEDURES

All underwater procedures covered under the section on Air Deep Sea Gear apply to helium-oxygen diving. In addition:

1. Maintain 100 psi supply pressure over bottom pressure for all divers.
2. If the diver develops symptoms of inadequate ventilation, he should immediately bypass the venturi supply by opening his control valve. To compensate for excess gas supply, the chin button will have to be used more frequently to prevent blow-up.
3. All divers and tenders must know and be alert to recognize the symptoms of oxygen poisoning. Remember the symptoms by V-E-N-T-I-D, (Vision-Ears-Nausea-Twitching-Irritability-Dizziness).
4. While breathing oxygen, remain as quiet as possible.
5. The specified maximum duration of a canister load of Baralyme is 3 hours. Adherence to this maximum usage will ensure a 200 percent safety factor.

MK VI SEMI-CLOSED DIVING APPARATUS





PREDIVE PROCEDURES

(To be conducted by the Dive Supervisor)

1. ☐ Break out and check all equipment to be used by the diver.

MINIMUM EQUIPMENT

- ☐ Swim trunks
- ☐ Mk III yoke-type life preserver
- ☐ Belt and knife
- ☐ Fins
- ☐ Face mask
- ☐ Semi-closed scuba MK-VI

OPTIONAL EQUIPMENT

- ☐ Depth gage
- ☐ Wristwatch
- ☐ Wrist compass

- ☐ Signal flare
- ☐ Slate
- ☐ Lifeline
- ☐ Floats
- ☐ Protective clothing
- ☐ Noseclip

2. ☐ Check the gas supply to insure that the mixture is correct as designated by the depth and duration of the dive.
3. ☐ Calculate the gas supply duration:

$$T = \frac{V\,(P - S)}{14.7F}$$

where, V = total cylinder volume, liters NPT
P = initial cylinder charge pressure, psi
S = low pressure safety limit = 20% of the cylinder pressure rating, psi
F = surface flow rate, liters per minute
T = gas supply duration, minutes

4. ☐ Check the descending line
5. ☐ Check the recompression chamber.
6. ☐ Take depth soundings.

EQUIPMENT PREPARATION

(To be conducted by the diver)

With the apparatus laying on a clean work surface, the diver will perform the following operational checks and adjustments prior to each use of the apparatus:

1. ☐ Remove the canister assembly from the back plate.
2. ☐ Remove the regulator assembly and control block assembly from the back plate.
3. ☐ Recharge the cylinders with the proper gas mixture selected for the dive (3,000 psi maximum).

WARNING:
Oil coming in contact with high pressure connections may result in an explosion. Use no oil.

4. ☐ Remove the access cap from the control block; install the appropriate filter and orifice assembly and replace the access cap.
5. ☐ Remove the canister assembly and fill it with Granular Baralyme. Check the duration of the absorbent at the water temperature.
6. ☐ Secure the regulator assembly and control block assembly to the back plate.
7. ☐ Secure the filled canister assembly to the back plate.
8. ☐ Adjust the regulator assembly for the required pressure depending on the filter and orifice assembly used in the control block. (8 liter per minute–80 psi, 12 lpm–140 psi, 21 lpm–180 psi).
9. ☐ Adjust the control block assembly to the proper liter flow.
10. ☐ Calibrate the differential pressure gauge.
11. ☐ Check the breathing apparatus for leakage by submerging it in water.
12. ☐ Check the mouthpiece T-tube assembly to insure that the check valves are operational.
13. ☐ Don the apparatus and accessory diving gear.

PREDIVE INSPECTION

(To be conducted by the Diving Supervisor)

1. ☐ Verify that all items listed under equipment preparation have been completed satisfactorily.
2. ☐ Check that the manifold shutoff valve is open and that the mouthpiece is in the DIVING position.

3. ☐ Review the mission and dive profile with the diver.
4. ☐ Check the diver's buddy or tender.
5. ☐ Have the diver enter the water.

POSTDIVE PROCEDURES

1. ☐ Close the manifold shutoff valve and the mouthpiece valve.
2. ☐ Rinse the breathing apparatus in clean, fresh water. Clean all breathing passages with medicated soap.
3. ☐ Remove drain plugs from the breathing bags and allow bags to dry thoroughly.
4. ☐ Drain Granular Baralyme from the canister and rinse out the canister.
5. ☐ Recheck the regulator flow. If it has changed more than ten percent from the predive reading, examine the regulator assembly and, if possible, correct the cause of the malfunction.
6. ☐ If equipment is to be stored, take all fabricated parts and use an approved preservative on all rigid parts and fittings. Unlatch the cylinder straps, close the manifold valve, bleed the bypass and back off on the regulator spring button. Stow the equipment in protective boxes in a cool, dry place.

UNDERWATER PROCEDURES

All underwater procedures covered under the section on air SCUBA apply to helium-oxygen SCUBA. In addition:

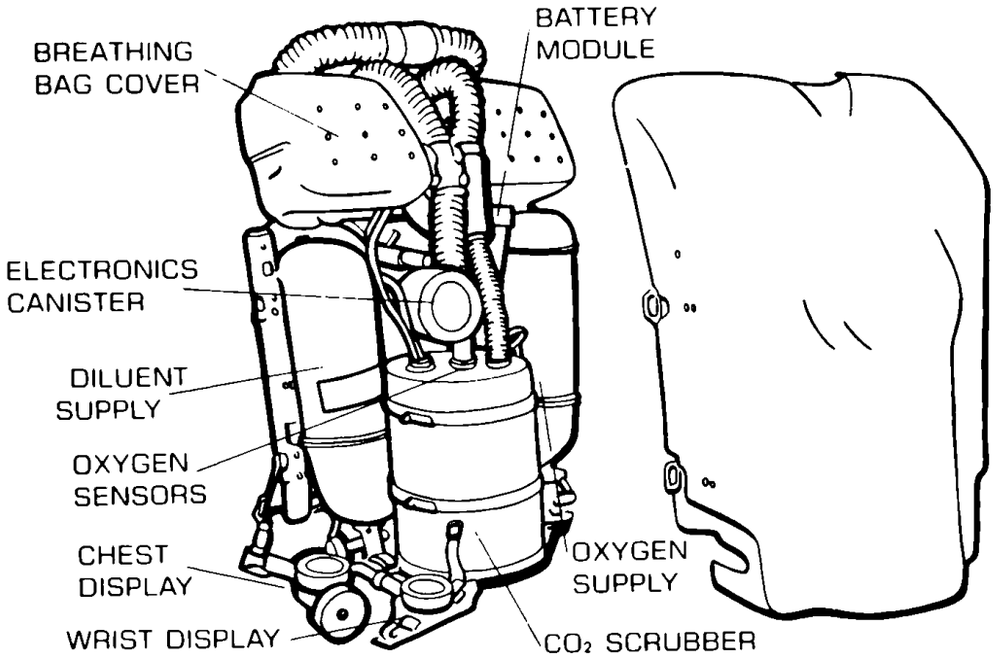
1. Descend at a rate to prevent squeeze of the breathing bag. It may be necessary to occasionally use the bypass.
2. Keep the breathing bags inflated to about two-thirds capacity.
3. At depth, work normally. Avoid extreme exertion unless the flow of the apparatus was previously set for heavy work.
4. Continuously watch the exhaust valve. The valve should operate at least every third breath.

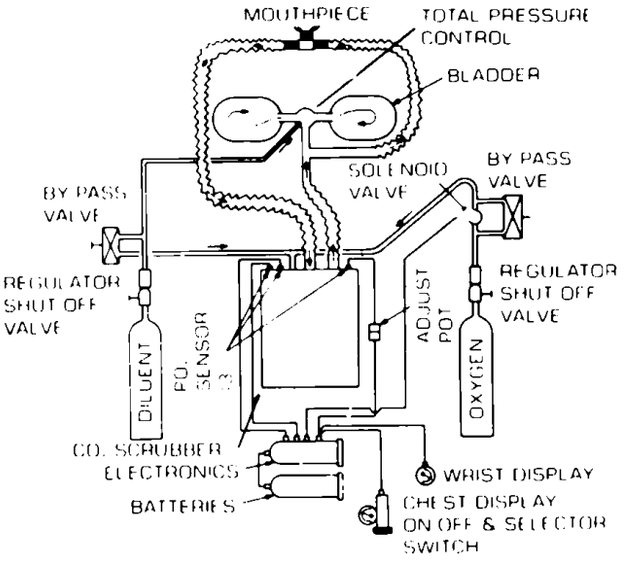
WARNING
Gas exhausting from the exhaust valve is the divers best indicator that the gas supply is operational. If this flow stops, carry out emergency procedures for injector failure immediately.

5. Do not overstay the duration time for the apparatus.
6. Prior to commencing the ascent, flush the breathing bags by using the bypass.
7. If the apparatus does not have an oxygen supply:
   (a) No decompression required–stop at 30 feet and flush the breathing bag, then complete the ascent.
   (b) Decompression required–ascend to first stop and flush the breathing bag (if first stop is above 30 feet, stop at 30 feet and flush breathing bag before coming to first stop). Complete decompression as required, flushing the breathing bag upon arrival at each stop.
8. If the apparatus does have an oxygen supply:
   (a) Ascend to first decompression stop. If first stop is deeper than 30 feet, flush breathing bag with mixture in use. Complete decompression stops as required, flushing the breathing bag upon arrival at each decompression stop up to 30 feet.
   (b) Upon arrival at 30 feet, turn off the mixed gas supply and turn on the oxygen supply, then flush the breathing bag with oxygen. Complete decompression stops as required.

WARNING:
Shift to oxygen must be made at 30 feet even if first stop is at 20 feet.

MK X MOD 3 CLOSED CIRCUIT UNDERWATER BREATHING APPARATUS





PREDIVE PROCEDURES

(To be conducted by the Dive Supervisor)

1. ☐ Breakout and check all diving equipment:

MINIMUM EQUIPMENT

- ☐ MK-X Mod 3 SCUBA
- ☐ Face Mask
- ☐ Fins
- ☐ Knife

OPTIONAL EQUIPMENT

- ☐ Protective Clothing
- ☐ Weight Belt
- ☐ Depth Gauge
- ☐ Wrist Watch
- ☐ Wrist Compass
- ☐ Signal Flares
- ☐ Float
- ☐ Slate/Stylus
- ☐ Noseclip

2. ☐ Check the ship's oxygen supply cylinders to ensure that they are tagged either Type A or Type B oxygen. Check the cylinder valves and all fittings.
3. ☐ Check that the ship's diluent gas supply is charged with the correct mixture designated for the depth of the dive.
4. ☐ Check the recompression chamber.
5. ☐ Take depth soundings.

EQUIPMENT PREPARATION

(To be conducted by the Diver)

1. ☐ Check the status of the apparatus from the log of the previous dive. Any discrepancies that have not been resolved must be satisfactorily corrected before continuing.
2. ☐ Check the complete assembly: All components present and clean, joints tight, no visual damage from handling or storage.
3. ☐ Insure that the batteries are fully charged.
4. ☐ Check that the oxygen partial pressure sensors are within ±5 percent of the actual PO_2 at the sensor face. Calibrate the sensors if necessary.
5. ☐ Check that the alarm system is operational.
6. ☐ Verify that the solenoid valve is operational.
7. ☐ Remove and charge the oxygen and the diluent gas cylinders to a pressure, up to 3000 psi, sufficient to perform the planned dive. Replace the cylinders in the apparatus.
8. ☐ Check that the oxygen and diluent gas supplies' bypass valves are operational.
9. ☐ Install a **new** disposable CO_2 absorbent cartridge in the scrubber canister. Check the duration of the absorbent at water temperature.

   WARNING:
   It is essential that a new cartridge be installed prior to each dive. Proper installation provides a water-tight seal between the cartridge and the container. Failure to install a new cartridge properly could result in CO_2 buildup in the breathing gas which could be fatal to the diver.

10. ☐ Verify that the diluent add valve is operational.
11. ☐ Verify that the vent valve is operational.
12. ☐ Check the complete apparatus for leaks.
13. ☐ Don the apparatus and accessory diving gear.

PREDIVE INSPECTION:

(To be conducted by the Dive Supervisor)

1. ☐ Verify equipment preparation.
2. ☐ Check that the gas cylinder valves are open. Switch the controls to automatic in the low range. Have the diver breathe the unit and check that the desired level at O_2 is automatically maintained and that the lights on the wrist and chest display are working properly. Repeat this operation on the high range.
3. ☐ Turn the selector knob on the chest display to the selected PO_2 control range, HIGH or LOW, and attach the display to the D-ring on the right shoulder harness.
4. ☐ Review the mission and dive profile with the diver.
5. ☐ Have the divers enter the water.

SURFACE CHECKOUT:

(To be conducted by the diver immediately upon entering the water)

1. ☐ Have the buddy diver check apparatus for leaks.
2. ☐ Check that the amber light on the wrist display is on.

POST DIVE PROCEDURES:

1. ☐ As the diver leaves the water, the Dive Supervisor is to check him for signs of sickness or injury that may have resulted from the dive.

2. ☐ Close the oxygen and diluent cylinder valves.

   If the cylinders are not going to be used for an extended period, the cylinder pressure should be 300 ±50 psig.

   CAUTION:
   Never allow cylinder pressure to decrease below 50 psig.

3. ☐ Open the mouthpiece; operate the bypass valves to bleed the lines; close the mouthpiece.
4. ☐ Remove the cover and rinse the apparatus and accessory diving equipment with clean, fresh water.
5. ☐ Remove and **discard** the disposable CO_2 absorbent cartridge. Wipe the inside of the canister.
6. ☐ Remove the mouthpiece and hose assembly and the breathing bags. Flush clean with zephivan chloride solution. Hang vertically to dry.
7. ☐ Check and log the sensor readings, battery voltage, HIGH and LOW PO_2 settings, alarm lights, and solenoid operation.
8. ☐ Attach the battery charger to the battery module. Turn on the battery charger.
9. ☐ Visually inspect all components for damage. Log all deficiencies.
10. ☐ Correct all deficiencies.
11. ☐ When the battery is charged and all components are dry, reinstall all removed components, except for the CO_2 absorbent cartridge. Store apparatus in a rigid container in a clean, dry location.

UNDERWATER PROCEDURES:

All underwater procedures covered in the section of air SCUBA apply to MK-X Mod 3 Close Circuit SCUBA In addition:

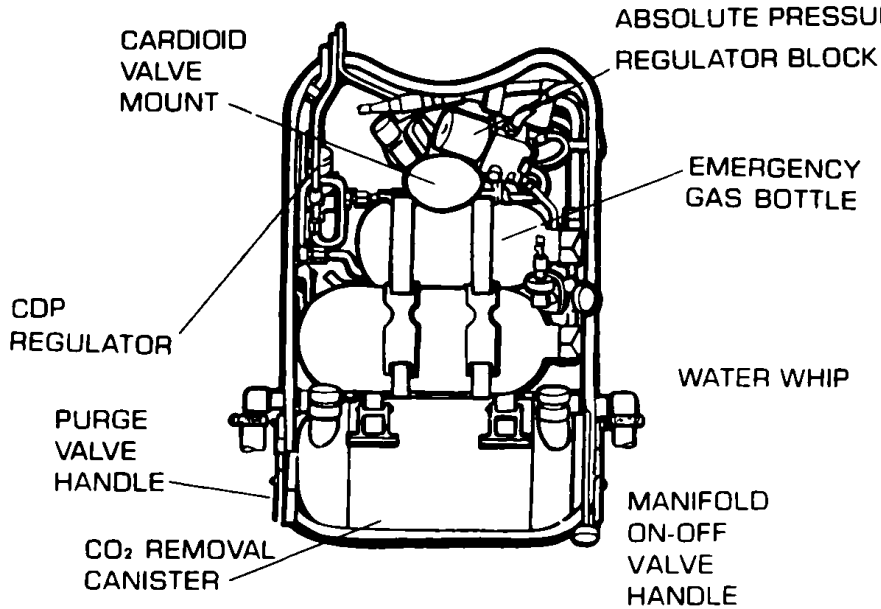
1. The MK-X Mod 3 apparatus is functioning properly when the **amber** light on the wrist display is ON.
2. If the amber light goes out and the red light comes on. Any or all of three conditions may exist.
   (a) The output of Sensor 1 is at least 25% above or below the desired operating pO_2 level.
   (b) The output of Sensor 2 is at least 25% above or below the desired operating pO_2 level.
   (c) Battery voltage is less than 22.5 vdc.
3. If the red light comes ON **and** remains on for an extended period, switch the selector on the chest display to the OFF position and go on manual control of the apparatus. TERMINATE THE DIVE.

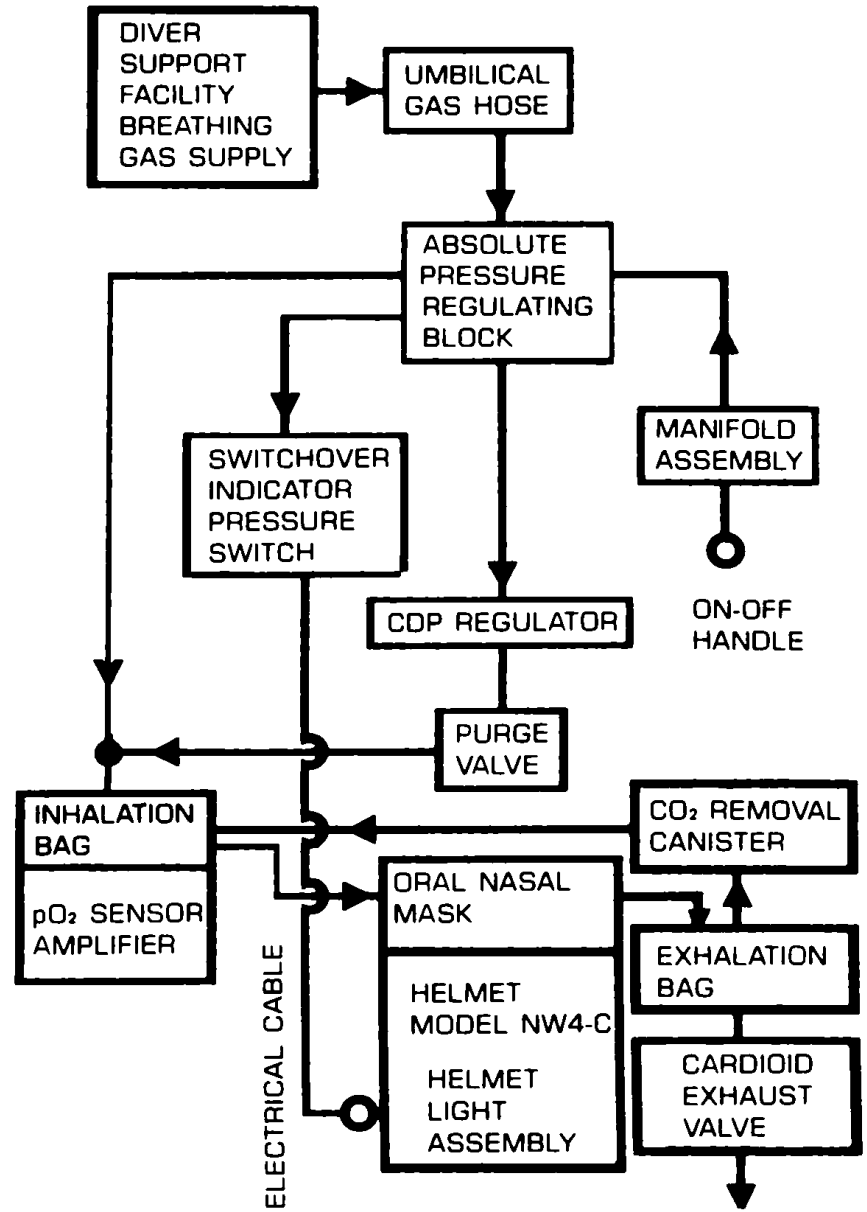
   NOTE:
   Conditions can exist such that the red light comes on for a brief period. If **all** three sensors indicate the same increased PO_2 level **and** the PO_2 level is slowly decreasing, do not terminate the dive. If both of the above conditions do not exist, switch to manual operation and terminate the dive.

4. If both indicator lights are on or off simultaneously, switch to manual operation and TERMINATE THE DIVE.
5. Monitor the wrist display frequently during the dive.

   CAUTION:
   The diver must know and be constantly alert for the following symptoms of oxygen poisoning: (V-E-N-T-I-D, Vision - Ears - Nausea - Twitching - Irritability - Dizziness). If symptoms occur, switch to manual operation, lower the PO_2 level by adding diluent to the breathing gas and terminate the dive.

MK XI MOD 0 DIVING APPARATUS





PREDIVE PROCEDURES

(To be conducted by the Dive Supervisor).

1. ☐ Break out and check all the diving equipment.

MINIMUM EQUIPMENT

- ☐ Hot water suit
- ☐ Knife
- ☐ Diver monitor
- ☐ Semi-closed Scuba MK XI-Mod O
- ☐ Umbilical

OPTIONAL EQUIPMENT

- ☐ Compass
- ☐ Depth indicator
- ☐ Weighted shoes
- ☐ Slate & stylus
- ☐ Fins

2. ☐ Check the gas supply to insure that the mixture is correct as designated by the depth and duration of the dive.

EQUIPMENT PREPARATION

(To be conducted by the diver)

1. ☐ Check that the field test kit, charging assembly, bib-whip and electrical checkout whip are on hand and operational.

2. ☐ Remove the manifold assembly from the backpack and, using the charging assembly, fill the cylinders to 3000 $^{+50}_{0}$ psig with the proper helium-oxygen mixture. Replace the manifold assembly in the backpack.

CAUTION

Do not fill the manifold assembly cylinders at more than 500 psig per minute.

3. ☐ Remove the CO_2 absorbent canister from the backpack and fill it with Granular Baralyme (about 10 pounds). Set canister aside. Check the duration of the absorbent at water temperature.

4. ☐ Connect the backpack electrical whip to the electrical checkout whip and check the communication system.

5. ☐ Calibrate the oxygen partial pressure monitoring system using the field test kit and bib-whip.

6. ☐ Check the switchover indicator system to insure that the helmet warning light will turn on when the manifold assembly pressure drops 300 psi (from 3000 psi to 2700 psi).

7. ☐ Adjust the constant differential pressure (CDP) regulator output pressure to twice the anticipated maximum dive depth pressure plus 40 psi minus the diver support facility ambient pressure in psia.

8. ☐ Install the sonic orifice, as specified by the diving supervisor, in the absolute pressure regulator block (APRB) and check to insure that the liter flowrate is as specified for the orifice. Adjust the CDP regulator as required.

NOTE

If the CDP output pressure must be changed to provide the specified liter flowrate, recheck the output pressure reading and record its new value.

9. ☐ Set the diver support facility regulator output pressure to 100 psi above the CDP regulator output pressure. Insure that the liter flowrate from the diver support facility is as specified. Increase diver support facility regulator output pressure as necessary to achieve the required flowrate.

10. ☐ Check that the exhaust valve opening pressure is no less than 0.30 psig when the valve spring is above the diaphragm and no less than 0.10 psig when the valve spring is below the diaphragm.

11. ☐ Replace the CO_2 removal canister in the backpack.

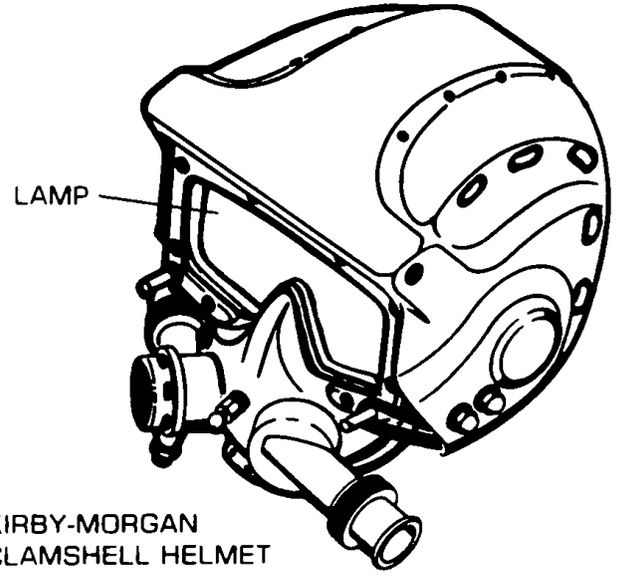
12. ☐ Check the high-pressure and low-pressure circuitry for leaks.

13. ☐ Don the hotwater suit, MK XI Mod O Scuba, helmet and accessory gear. Check the inhalation and exhalation check valves.

PREDIVE INSPECTION

(To be conducted by the Dive Supervisor)

1. ☐ Verify equipment preparation.
2. ☐ Check that the diver's umbilical gas hose, electrical cable and strain relief line are connected properly to the diver and the support facility.
3. ☐ Check the diver's communications.



KIRBY-MORGAN
CLAMSHELL HELMET

SWITCH-OVER INDICATOR WARNING LAMP –
LIGHTS WHEN USING EMERGENCY GAS SUPPLY

4. ☐ Connect the helmet to the two breathing hoses and the helmet warning light cable to the pressure switch cable. Check that the helmet warning light is glowing.
5. ☐ Turn the manifold on-off valve **on**. Check that the helmet warning light goes off.
6. ☐ Actuate the purge valve to insure that it is functioning correctly.
7. ☐ Screw the helmet valve onto the second stage regulator on the helmet.
8. ☐ Open the helmet on-off valve and press the demand button to ensure that it is functioning correctly. **Close** the helmet on-off valve.
9. ☐ Actuate and check the oxygen partial pressure monitoring system.
10. ☐ Connect the hot water supply hoses.
11. ☐ Review the mission and dive profile with the diver.
12. ☐ Check the diver's buddy or tender.
13. ☐ Have the diver breathe on the apparatus for at least two minutes then place him in the water.

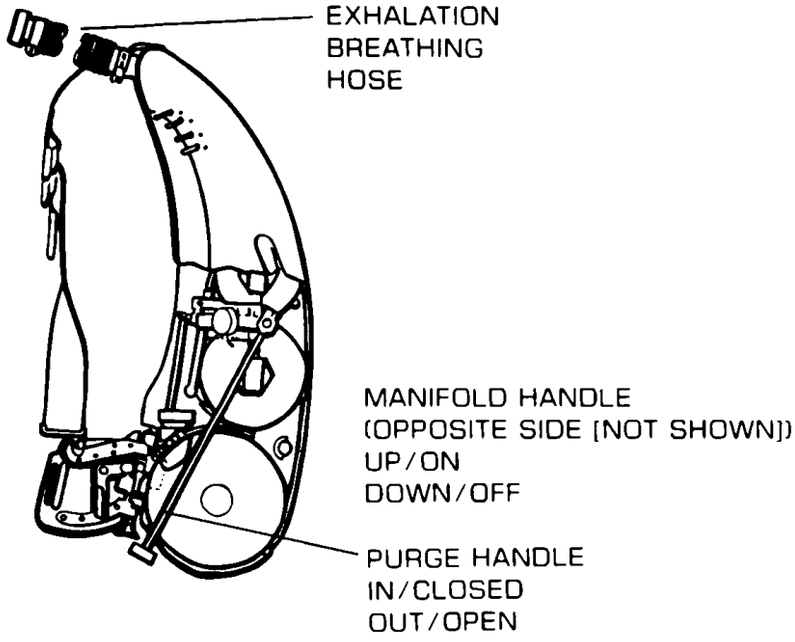
SURFACE CHECKOUT

(To be conducted by the diver immediately upon entering the water)

1. ☐ Check for leaks about the apparatus.
2. ☐ Check the communications.
3. ☐ Check for pO_2 readout.
4. ☐ Check the purge valve.
5. ☐ Check the demand supply.

UNDERWATER PROCEDURES

1. ☐ If the helmet faceplate fogs, lower the head below breathing bag level and press the water purge button. A small amount of water should be left in the helmet to rinse fog off the faceplate.
2. ☐ Adjust the hot water bypass valve and front and rear flow control valve to achieve maximum comfort.



3. ☐ Periodically check the manifold assembly on-off handle to insure that it is on.
4. ☐ If the helmet warning lamp comes on, return to the diver support facility.
5. ☐ If floodout occurs, open the helmet valve and pinch off the inhalation (right) hose.
6. ☐ If floodout and umbilical pressure drop occur, make sure that the manifold assembly on-off valve is on, open the helmet valve, pinch off the inhalation hose and return to the diver support facility.
7. ☐ If the rig must be abandoned, push in and down on the shoulder strap retaining levers, actuate the waist buckle quick release mechanism and disconnect the hot water suit hose. When free of the backpack, pull forward on the helmet faceplate and lift the helmet free of the head.
8. ☐ If symptoms of inadequate ventilation develop, purge the helmet immediately.

POSTDIVE PROCEDURES

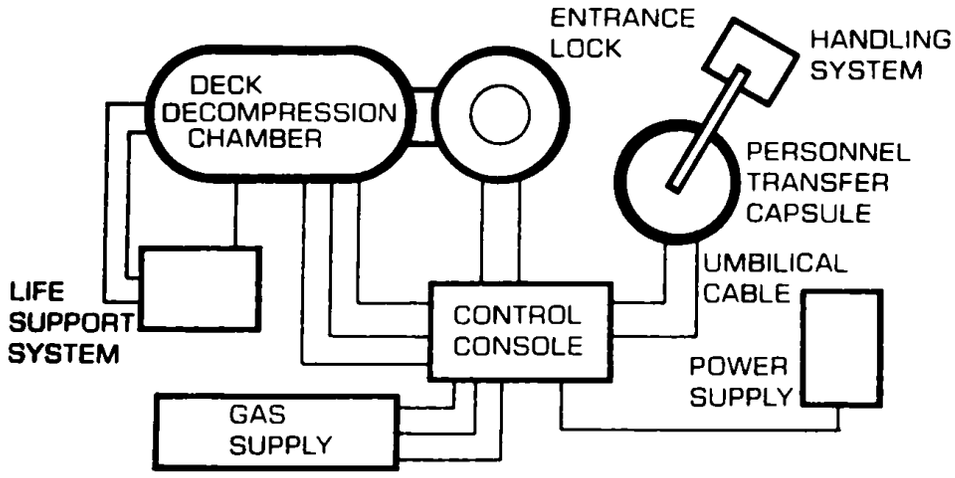
1. ☐ As the diver leaves the water, the Dive Supervisor is to check him for any signs of sickness or injury that may have resulted from the dive.
2. ☐ Remove the diving apparatus and accessory equipment.
3. ☐ Ensure that the manifold assembly on-off valve is in the OFF (down) position.
4. ☐ Disconnect all hoses and cables from the MK XI Mod O and helmet.
5. ☐ Rinse all equipment in clear, fresh water.

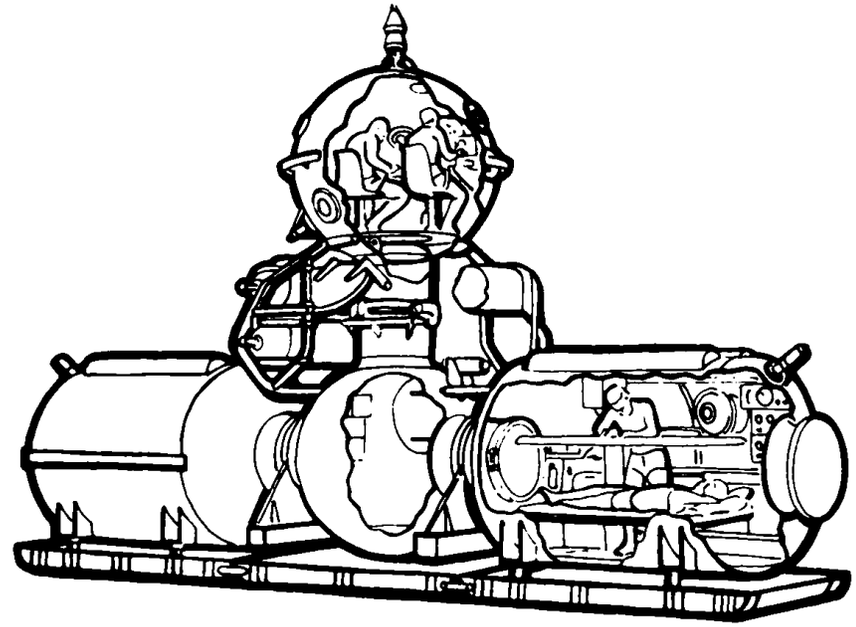
CAUTION

Do not allow water to enter the absolute pressure regulator block or manifold assembly. If it does, rinse with fresh water and dry with dry gas.

6. ☐ Remove the CO_2 absorbent canister, empty out the used absorbent, rinse with fresh water and dry.
7. ☐ Rinse out the breathing bags with fresh water and dry with dry gas.
8. ☐ Remove the pO_2 sensor-amplifier and cover it with its storage cover.
9. ☐ Store the hot water suits on hangers in a cool, dry place.

DEEP DIVING SYSTEMS





PREDIVE CHECKOUT

The following checklist applies to deep diving systems in general and is designed to direct attention to the primary components of the system. All U.S. Navy deep diving systems have checkout procedures included in their operations and maintenance manuals which must be completed prior to every dive. Since all deep diving systems are not identical, some of the components mentioned in the following procedures may not exist on the system under consideration and should be ignored.

PERSONNEL TRANSFER CAPSULE (PTC):

1. ☐ Check the supply pressure of the oxygen, helium and mixed gas cylinders. Pressurize as required.
2. ☐ Check that all fittings are tight, valves properly positioned and gages calibrated.
3. ☐ Check the main electrical system; scrubber motors, lights, etc.
4. ☐ Check the emergency electrical system.
5. ☐ Check the primary and emergency mixed gas supply system.
6. ☐ Check the oxygen supply system and masks.
7. ☐ Check the helium purge system.
8. ☐ Check the exhaust system.
9. ☐ Check the Baralyme in the CO_2 scrubber. Fill or replace as necessary.
10. ☐ Check hatch seats and O-rings. Clean and lubricate as necessary.
11. ☐ Check the communications system.
12. ☐ Check the closed circuit television system.
13. ☐ Check the ballast release/retrieval system.
14. ☐ Check the oxygen monitoring system.
15. ☐ Check that all accessory equipment is installed; tools, headgear, stopwatches, diving gear, etc.

DECK DECOMPRESSION CHAMBER (DDC) AND ENTRANCE LOCK (EL):

1. ☐ Check that all fittings are tight, valves properly positioned and gages calibrated.
2. ☐ Check the helium purge system.
3. ☐ Check the mixed gas supply system.
4. ☐ Check the oxygen supply system and masks.
5. ☐ Check the exhaust system.
6. ☐ Check the electrical system; scrubber motors, lights, etc.
7. ☐ Check the Baralyme in the CO_2 scrubbers. Fill or replace as necessary.
8. ☐ Check the medical lock(s).
9. ☐ Check the hatch seats and O-rings. Clean and lubricate as necessary.
10. ☐ Check the communications system.
11. ☐ Check the closed circuit television system.
12. ☐ Check that all accessory equipment is installed; tools, blankets, diver's personal items, etc.
13. ☐ Check the fresh water supply system; sink, shower, toilet.
14. ☐ Check that the fire suppression system is charged and operational.
15. ☐ Check that the PTC/EL mating system is operational.

CONTROL CONSOLE; GAS SUPPLY; POWER SUPPLY:

1. ☐ Check that all fittings are tight, valves properly positioned and gages calibrated.
2. ☐ Check the bottle pressure, supply pressure (regulator settings) and mixture of the mixed gas supply systems.
3. ☐ Check the bottle pressure and supply pressure (regulator settings) of the oxygen supply system.
4. ☐ Check the air supply systems; compressors, regulator settings, filters, etc.
5. ☐ Check the primary and emergency power supply systems.
6. ☐ Check the communication system.
7. ☐ Check the closed circuit television system.
8. ☐ Check the oxygen monitoring system.
9. ☐ Check the CO_2 monitoring system.
10. ☐ Check the stopwatches and clocks.
11. ☐ Check that the decompression tables are accessible.

LIFE SUPPORT SYSTEM:

1. ☐ Check that all fittings are tight, valves properly positioned and gages calibrated.
2. ☐ Check the air cooling system; freon charged, glycol full, water system, etc.
3. ☐ Check the heating system.

HANDLING SYSTEM:

1. ☐ Check that the lift system is operational; winch, crane, controls.
2. ☐ Check the lift cables and fittings.

UNDERWATER PROCEDURES

1. Checkout all systems.
2. Divers enter the PTC, and close and dog the external hatch.
3. Divers activate the CO_2 removal and oxygen monitoring systems.
4. Take up slack on lift cable; remove PTC hold-down cables.

5. Attach steadying lines to the PTC; man the lines.
6. When divers indicate that they are secure, lift the PTC over the side of the vessel.
7. Lower the PTC through the air/water interface as rapidly as possible to obtain a hatch seal and clear the PTC from this potential hazard zone.
8. Have divers remove the steadying lines from the PTC.
9. Lower the PTC to the work or observation site.

OBSERVATION DIVES:

10A. In the observation mode of diving, the divers must concern themselves primarily with monitoring the oxygen partial pressure level and CO_2 concentration in the PTC atmosphere. Add oxygen and operate the scrubber as required to maintain a life sustaining environment inside the PTC.

11A. Upon completion of the task, the divers notify the vessel that they are ready to come up.

12A. The PTC is lifted to just below the air/water interface and held there while the surface divers fasten on the steadying lines.

13A. The PTC is lifted aboard the vessle and secured to the deck.

14A. Take the strain off the lifting line, open the lower hatch and exit the divers from the PTC.

15A. Conduct postdive checkout of the deep diving system.

AMBIENT PRESSURE DIVES:

10B. Upon reaching the worksite, one of the divers dresses for the dive.

11B. When ready to exit the PTC, undog the lower hatch and pressurize the PTC using either surface supplied or PTC supplied gas until the internal gas pressure equals the external water pressure. Bottom time begins as soon as pressurization commences.

12B. The diver opens the lower hatch, enters the water and performs his task while his buddy tends him from inside the PTC.

13B. When completed with the task, or exhausted, the diver returns to the PTC, enters and removes his diving gear.

14B. If necessary, the second diver dresses and enters the water to complete the task. Upon completion, he returns to the PTC and removes his diving gear.

15B. When ready to come up, the divers close and dog the lower and upper hatches.

16B. When the divers signal ready, the PTC is lifted to just below the air/water interface. When coming off the bottom, care must be taken to ensure that a proper hatch seal is obtained.

17B. Lift the PTC aboard the vessel. If it is impractical to decompress the divers inside the PTC, mate the PTC to the EL. (The DDC and EL should be pressurized prior to lifting the PTC off the bottom.)

18B. Equalize the pressure between the PTC and EL and have the divers enter the DDC via the EL, closing and dogging the EL upper hatch behind them.

19B. Complete diver's decompression inside the DDC.

20B. Depressurize the PTC, lift it off the EL, lower it to the deck and secure it with tie-downs.

21B. Conduct postdive checkout of the deep diving system.

POSTDIVE CHECKOUT

PERSONNEL TRANSFER CAPSULE

1. ☐ Gas supply system; secure valves, check for damage, bleed lines.
2. ☐ Electrical system; turn switches off, place battery on charge, clean plugs and connectors.
3. ☐ Communications system; operational, replace speakers if necessary.
4. ☐ Monitoring system; remove and store oxygen pO_2 sensor, stock CO_2 concentration sensor (chemicals).
5. ☐ Structural; check for hull or stand damage, check viewports and penetrations for cracks or damage, check hatch seats and O-rings for damage.
6. ☐ Diving gear; check for umbilical damage, clean and store properly.
7. ☐ Wash the PTC with fresh water.
8. ☐ Wipe all moisture, oil and grease from inside the PTC.
9. ☐ Lubricate hatch seats and O-rings.

DECK DECOMPRESSION CHAMBERS AND ENTRANCE LOCK

1. ☐ Gas supply system.
2. ☐ Electrical system.
3. ☐ Communication system.
4. ☐ Monitoring system.
5. ☐ Clean and wipe dry the inside of the DDC and EL.
6. ☐ Clean and dry blankets and mattresses. Replenish any consumables used during dive.
7. ☐ Clean and lubricate hatch seats and O-rings.

CONTROL CONSOLE:

1. ☐ Bleed all regulators and lines. Secure valves.
2. ☐ Secure all electrical components and communication gear.
3. ☐ Complete all logs.
4. ☐ Secure stopwatches and clocks.
5. ☐ Clean and wipe dry.

GAS SUPPLY:

1. ☐ Check supply lines and hoses.
2. ☐ Secure air compressors.
3. ☐ Check supply pressures of all gases and recharge or replace bottles if necessary.

HANDLING SYSTEM:

1. ☐ Check lift cable for damage that may have been received during the dive.
2. ☐ Secure winch.

LIFE SUPPORT:

1. ☐ Bleed lines and secure all valves.
2. ☐ Secure electrical system.
3. ☐ Fill with liquids as required; freon, glycol, water.

MIXED GAS SUPPLY

GAS MIXING:

1. **Safety Precautions**

   A. **WHEN OXYGEN UNDER HIGH PRESSURE COMES IN CONTACT WITH OIL OR GREASE, A VIOLENT EXPLOSION MAY OCCUR.**

   1. Make sure all piping components are free of oil and grease.
   2. Do not handle any parts that may come in contact with high pressure oxygen. Oil deposited by fingers could cause an explosion.
   3. Never mix a gas that might contain oil vapor with high pressure oxygen.
   4. Never allow the pressure inside an oxygen cylinder to fall below 25 psig. This will keep foreign material and gases from entering and contaminating the cylinder.
   5. When cleaning oxygen fittings use only approved cleaning procedures.

      NOTE:
      If a cylinder is known, or even suspected to have been contaminated it must be withdrawn from oxygen service and **painted**–
      CONTAMINATED.

   B. FAILURE OF ANY HIGH PRESSURE COMPONENT COULD SUDDENLY RELEASE GAS WITH A BLAST EFFECT SIMILAR TO AN EXPLOSION.

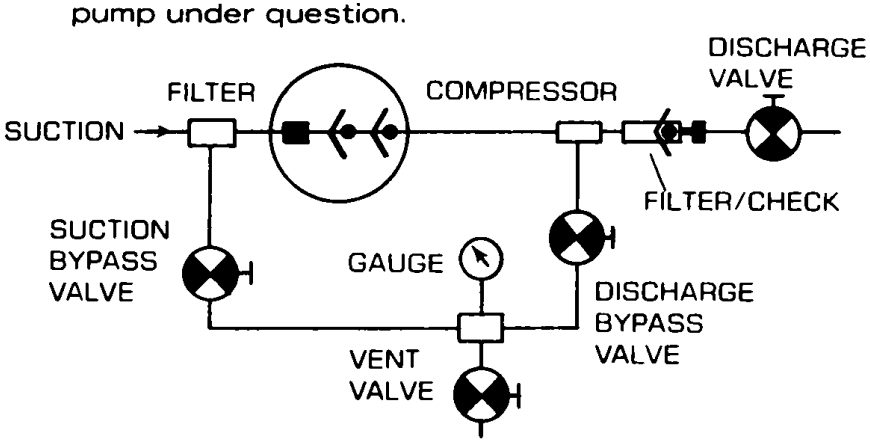
   1. In handling gas cylinders, a truck equipped with a suitable steadying device must be used, the cylinder valves must be securely closed and covered with valve caps.
   2. Never use a wrench or hammer to open a cylinder valve. Damage to the interior valve parts could result.
   3. Do not tamper with the safety plug. If the plug fractures, replace it with a plug designed for that particular type of cylinder.
   4. Never attempt to tighten or loosen a fitting under pressure.

   C. CYLINDERS MUST BE STOWED IN A DRY, COOL AREA; INCREASED TEMPERATURE CAUSES INCREASED PRESSURE WHICH COULD EXCEED THE RATED CYLINDER PRESSURE.

   1. Keep cylinder away from the direct rays of the sun.
   2. Keep cylinders away from highly combustible materials.
   3. Do not smoke near oxygen cylinders.

2. **Oxygen-Transfer Pump**

   The primary piece of equipment used in gas mixing is the oxygen-transfer pump, a diaphragm pump that uses either distilled water or Fluorolube as a pulsating fluid to actuate the diaphragm. A typical process flow schematic is shown in the figure below. Operation, checkout and maintenance procedures for an oxygen transfer pump should be taken from the technical manual for the specific pump under question.



3. **Single-Cylinder Mixing**

When mixing gas one cylinder at a time, use the following procedure: (Assume the gases to be mixed are helium and oxygen.)

a. Measure the pressure in the helium cylinder (P_{H})

b. Measure the pressure in the oxygen cylinder (P_{O})

c. Calculate the pressure in the helium cylinder after mixing (P_F):

$$P_F = \frac{P_H}{\text{Decimal percent helium in final mixture}}$$

d. Determine if there is sufficient pressure in the oxygen cylinder to accomplish mixing:

$2P_F - P_H + 50$ = Minimum pressure needed in oxygen cylinder. (This value must not be greater than P_O)

e. Connect the helium and oxygen cylinders together using a T-fitting. (See illustration below.)

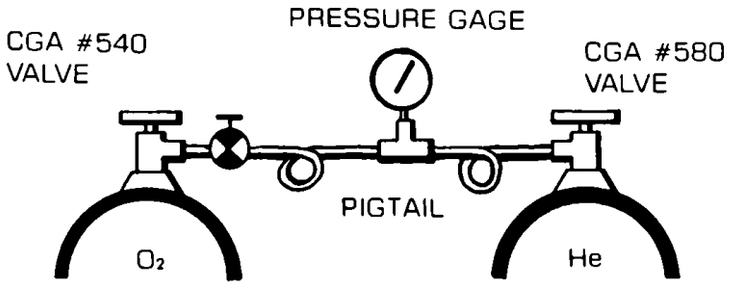
f. Open the helium cylinder valve.

g. Crack open the oxygen cylinder valve and bleed oxygen into the helium cylinder at a rate not to exceed 70 psi per minute, until the desired P_F is reached.

h. Close the oxygen cylinder valve and allow the temperature in the helium cylinder to return to room temperature.

i. Add oxygen to obtain the desired final pressure at room temperature.

j. Allow the helium-oxygen mixture to stabilize for 24 hours. Analyze the mixture and correct as necessary.



4. **Multiple-Cylinder Mixing**

When large quantities of a given gas mixture must be prepared use the following procedure: (Assume the gases to be mixed are helium and oxygen.)

a. Connect up a multiple-cylinder mixing manifold (See Cylinder Connections and Manifolding Section).

b. Open all the cylinder valves

c. Crack valve A to equalize the pressure in all the oxygen cylinders.

d. Crack valve B to "split" the helium gas.

e. Read the equalized pressure in the helium cylinders (P_H) (Gauges 3 and 4).

f. Calculate the pressure in the helium cylinders after mixing (P_F).

$$P_F = \frac{P_H}{\text{Decimal percent helium in final mixture}}$$

g. Read the equalized pressure in the oxygen cylinders (P_O)

h. Determine if there is sufficient pressure in the oxygen cylinders to accomplish mixing.

$2P_F - P_H + 50$ = Minimum pressure needed in oxygen cylinders. (This value must not exceed P_O)

i. Crack valve C (and valve D if two operators are available) and bleed oxygen into the helium cylinders at a rate not to exceed 70 psi per minute, until the desired P_F is reached.

j. Close valves C (and D) and allow the helium-oxygen mixture to cool to room temperature. This will cause the pressure in these cylinders to drop slightly.

k. Add oxygen until the desired P_F is obtained at room temperature.

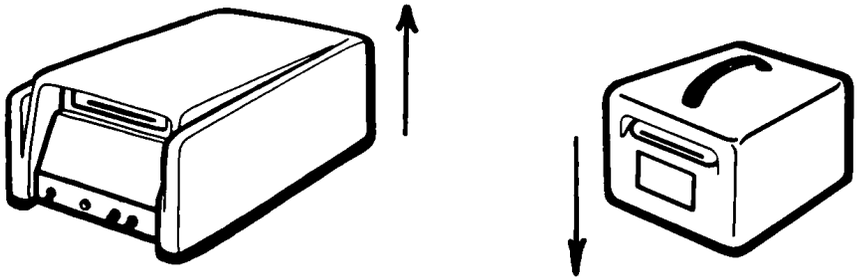
l. Allow the helium-oxygen mixture to stabilize for 24 hours. Analyze the mixture and correct as necessary.

GAS ANALYSIS

1. **Gas Analyzers**

A. Beckman Model C Oxygen Analyzer

The Beckman Model C Oxygen Analyzer provides a **continuous** analysis of the percent of oxygen in a mixture containing oxygen and an inert gas (helium-oxygen, nitrogen-oxygen). The reading is not affected by changes in the gas temperature and may be corrected for changes in barometric pressure, background gases and calibration errors. This instrument is accurate to ±1 percent of the full scale reading, with greater accuracy possible if the above corrections are made. A 115 volt ac. 50-60 cycle power supply is required for operation.

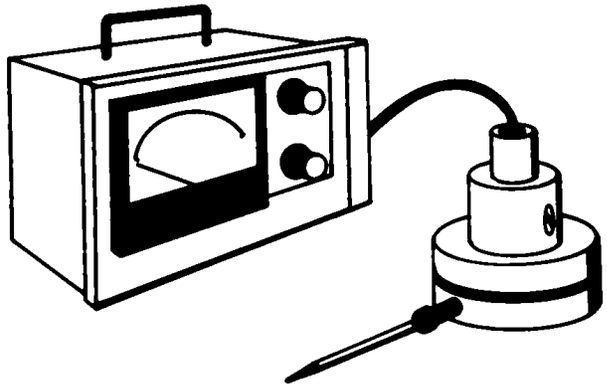


B. Beckman Model D Oxygen Analyzer

This is a battery powered (Size D flashlight cells) analyzer which provides an **intermittent** analysis of the percent of oxygen in a mixture of oxygen and some other inert gas. It is not temperature compensated and claims accuracies of only ±2 percent of the full scale reading at 75°F. With proper attention paid to calibration and corrections, better accuracy than this is possible; but without attention to these details, the results can be seriously misleading.

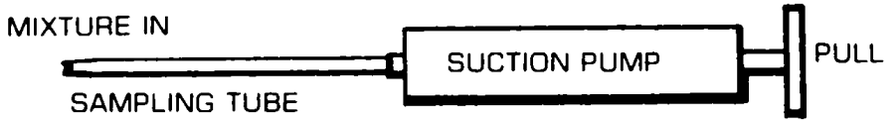
C. Beckman Model 715 Oxygen Analyzer

The model 715 Oxygen Analyzer provides a **continuous** analysis of the percent of oxygen in a gas mixture. In operation the gas being analyzed flows into the polarographic sensor via a flow meter. As the oxygen in the gas diffuses past a teflon membrane, it reacts with an electrolytic solution to give a voltage proportional to its percentage in the mixture. Percentages are accurate to ±1 percent full scale at constant temperature, but diminish rapidly as the gas temperature varies (±6 percent for variations between 32°F and 110°F; however, an optional heater will maintain the gas at a constant temperature). The model 715 has its own power source consisting of two 6.75v batteries and one 1.34v battery.



D. Carbon Dioxide and Carbon Monoxide Gas Analyzers

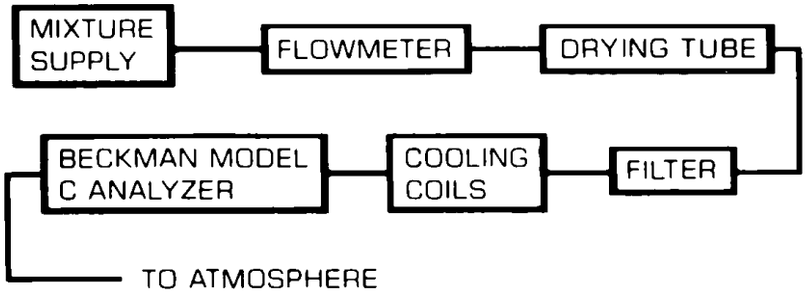
The most common apparatus used to measure the percent of CO_2 and CO (as well as many other extraneous gases if desired) in a gas mixture is the sampling pump/chemical indicator tube kit. The pump allows a controlled volume of the gas mixture to be sucked through a disposable glass tube which is filled with a chemical that discolors when it comes in contact with a specific gas (e.g., CO_2 or CO). The amount of discoloration is directly proportional to the concentration of the specific gas in the mixture.



2. Gas Analysis Procedures

BECKMAN MODEL C

a. Connect the apparatus as shown in the schematic.



b. Turn on the analyzer. Allow 30 minutes to warm up.

c. Calibrate the analyzer.

d. Run gas sample through the analyzer at a flow rate between 50 and 250 cc per minute.

e. Observe the reading and allow it at least 1 minute to stabilize.

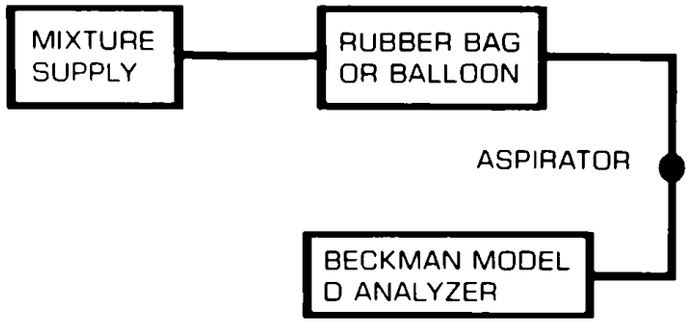
f. If the pilot light is glowing, wait until it goes out before taking the reading.

g. Take final reading and record it.

h. Make corrections as required.

BECKMAN MODEL D

a. Connect the apparatus as shown in the schematic.



b. Slowly squeeze the aspirator at least four times to ensure complete removal of the last sample.

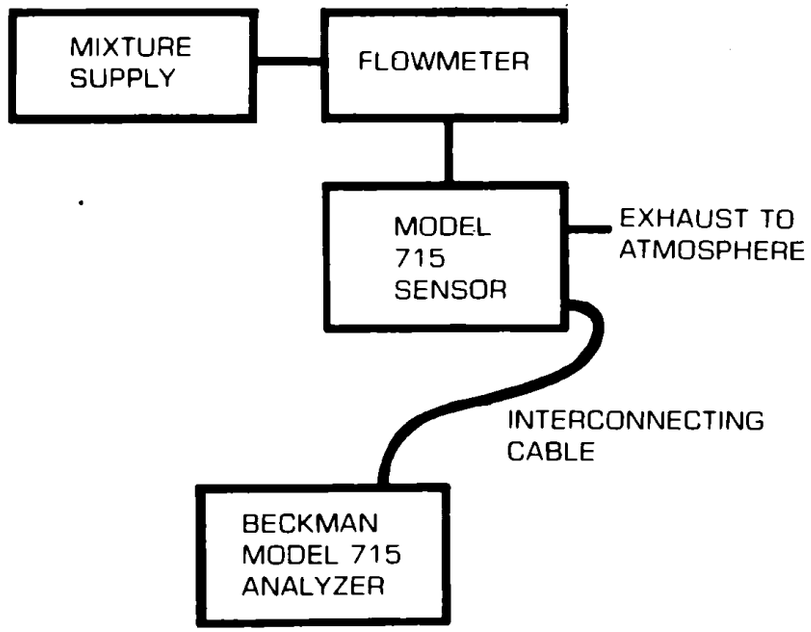
c. Press the light switch button on top of the instrument.

d. When light beam stops oscillating take the final reading.

e. Make corrections as required.

BECKMAN MODEL 715

a. Connect the apparatus as shown in the schematic.



b. Start up and calibrate the analyzer per the instruction manual.

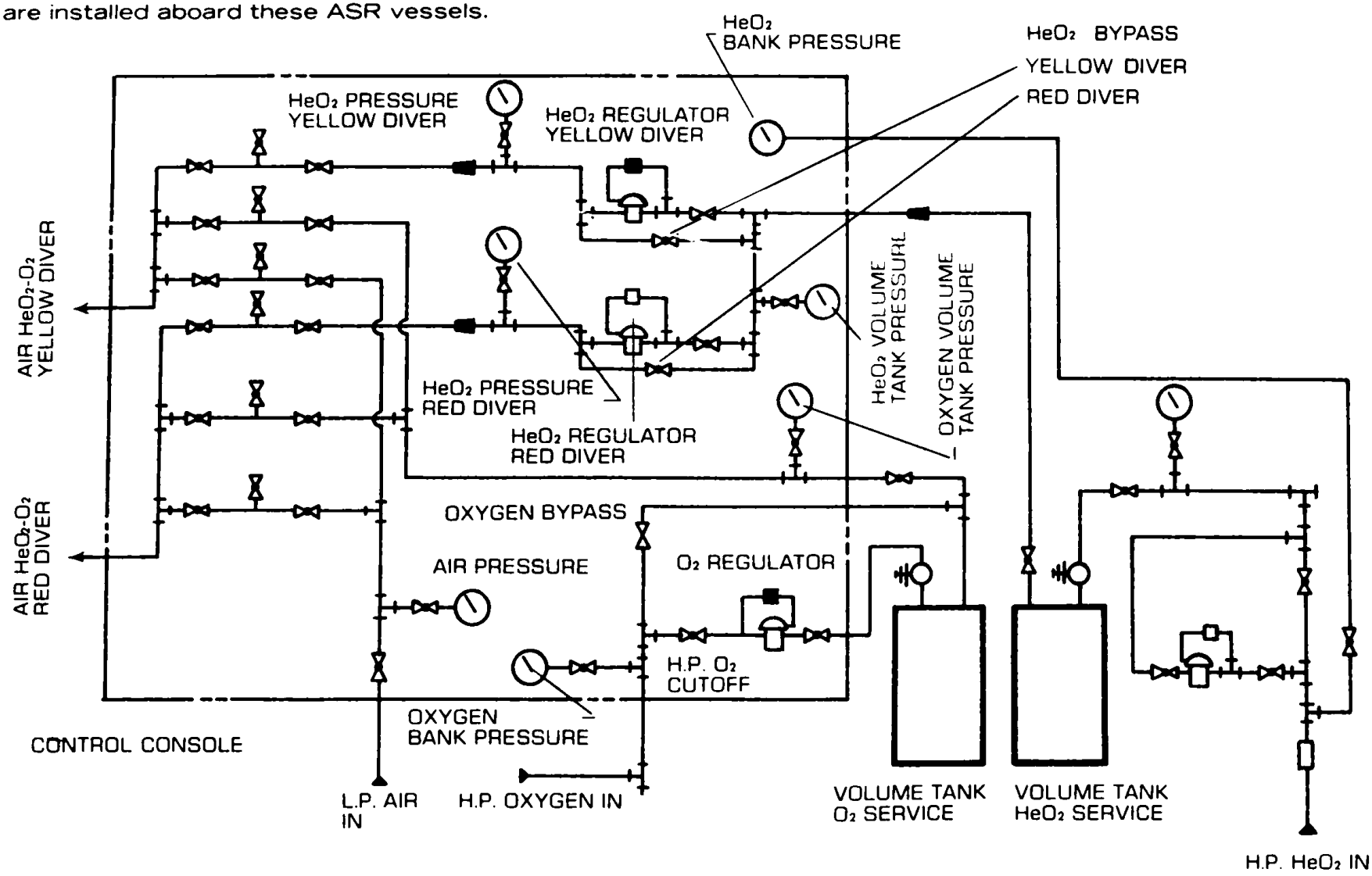
c. Flow gas through the sensor at a rate between 20 and 200 cc per minute.

d. Wait until the reading stabilizes and record it.

e. Make corrections for temperature as required.

ASR DIVER'S GAS SUPPLY PIPING SCHEMATIC

A typical diver's gas supply system, found aboard all ASR vessels equipted for mixed gas diving, is shown in the schematic below. Each system, as shown below, is capable of supplying either mixed gas, oxygen or air to two divers and two such systems are installed aboard these ASR vessels.



GAS USAGE LOG

The Dive Supervisor should fill out the gas usage log for every dive to ensure that the gas supplies never fall below an unsafe diving pressure.

Date:_____

Dive Start Time:_____

Dive Completion Time:_____

Dive Depth:_____

Predive Supply Pressures:

Mixed Gas _____% He _____% O_2 _____% N_2 = _____psi.

Mixed Gas _____% He _____% O_2 _____% N_2 = _____psi.

Helium = _____psi. Oxygen = _____psi. Compressed Air = _____psi.

Postdive Supply Pressures:

Mixed Gas _____% He _____% O_2 _____% N_2 = _____psi.

Mixed Gas _____% He _____% O_2 _____% N_2 = _____psi.

Helium = _____psi. Oxygen = _____psi. Compressed Air = _____psi.

Signature_____
Dive Supervisor

NOTES

SECTION 6—MIXED GAS DECOMPRESSION TABLES

INTRODUCTION

The Mixed Gas Decompression Tables are identical with those in the Diving Manual. Format is the same as that used in the Air Decompression Tables section and the general instructions have also been rewritten for increased clarity.

There are several important changes and additions in this section. The normal and exceptional exposure partial pressure tables have been combined. The exceptional Tables are printed in RED. A rotary selector chart has been provided which permits the direct dialing of the appropriate partial pressure table and also indicates the maximum allowable normal bottom time.

Saturation and saturation-excursion tables are included in the Handbook. These tables are new and require the authorization of the Supervisor of Diving prior to field use. Because of the unique nature of these tables they have been combined with saturation abort and treatment tables in a separate section of the Handbook.

BE ALERT FOR SYMPTOMS OF OXYGEN TOXICITY

DECOMPRESSION OF MIXED GAS DIVERS

GENERAL

Mixed gas diving permits operations to be performed at greater depth than air diving. A quantity of Helium is taken up by the body during every dive. As in air diving, the amount of inert gas absorbed depends upon the depth of the dive and the exposure (bottom) time. If the quantity of helium dissolved in the body tissues exceeds a certain critical amount, the ascent rate must be delayed to allow the body tissue to remove the excess helium. Decompression sickness results from failure to delay the ascent and to allow this process of gradual desaturation.

As a consequence of greater depth and longer exposure times encountered in mixed gas diving, the problem of oxygen toxicity is more pronounced. It is essential that the limits of oxygen exposure found in Tables 1-16 and 1-16a be rigidly met.

Many decompression procedures for mixed gas diving are similar to those for air diving. Prior to commencement of mixed gas operations the section of this Handbook entitled **"Decompression of Air Divers"** should be reviewed.

DEFINITIONS

RESIDUAL HELIUM
Helium gas still dissolved in divers body following completion of a dive.

RESIDUAL HELIUM TIME
See analogous definition for "RESIDUAL NITROGEN TIME" in section **Decompression of Air Divers.**

PARTIAL PRESSURE
The fraction of total absolute pressure of a gas mixture exerted by a single component of the mix, usually measured in atmospheres (absolute) or millimeters of mercury (mmHg) or feet of seawater.

OXYGEN TOXICITY

As a consequence of greater depth, longer exposure times and the capability to vary the amount of oxygen in the diver's breathing gas, the problem of oxygen toxicity is more pronounced in mixed gas diving than air diving. It is essential for diver safety that the depth and time of a dive be within the limits imposed by Table 1-16 to avoid hazardous partial pressures of oxygen. Use of oxygen partial pressure limits in Table 1-16a is restricted to situations of operational necessity or emergencies. The values given in these tables are for divers **at work** underwater. These values are normally exceeded in helium-oxygen deep sea diving in the shallow stages of decompression when the diver is **at rest.**

TABLE 1-16 OXYGEN PARTIAL PRESSURE LIMITS
(FORMERLY TABLE 1-11, 1963 DIVING MANUAL)

Exposure Time (min.)	Maximum Oxygen Partial Pressure (atmospheres)
30	1.6
40	1.5
50	1.4
60	1.3
80	1.2
120	1.1
240	1.0

TABLE 1-16a OXYGEN PARTIAL PRESSURE LIMITS FOR EXCEPTIONAL EXPOSURES
(FORMERLY TABLE 1-11, 1963 DIVING MANUAL)

Exposure Time (min.)	Maximum Oxygen Partial Pressure (atmospheres)
30	2.0
40	1.9
60	1.8
80	1.7
100	1.6
120	1.5
180	1.4
240	1.3

NOTE: The above tables are not applicable to mixed gas SCUBA tables.

SPECIFIC INSTRUCTIONS FOR USE OF MIXED GAS DECOMPRESSION TABLES

HELIUM-OXYGEN MIXED GAS SCUBA TABLES

The mixed gas SCUBA tables are similar in format and use to the air tables. Repetitive dive procedures are computed in the same manner as in air diving.

HELIUM-OXYGEN DECOMPRESSION TABLES

The $He\text{-}O_2$ decompression tables (1-23 and 1-23a) are primarily intended for use with mixed gas deep sea gear. They differ from the air tables in the following major respects:

1. The partial pressure of the inert gas at depth and not the depth of the dive determines the particular table to use.

2. The rate of ascent from the bottom to the first stop varies. Rate of ascent is found from the table as follows:

$$\text{Rate of Ascent To First Stop} = \frac{\text{Bottom Depth} - \text{Depth of First Stop}}{\text{Time to First Stop}}$$

3. Remain at first stop for the number of minutes indicated.

4. The rate of ascent between stops should be 60 ft./min. Include each time of ascent in the subsequent stop.

5. Ascend to surface at a uniform rate during the last minute of the 40 ft. stop.

6. The use of these tables requires an inwater switch to oxygen as the breathing medium for the 50 ft. and 40 ft. decompression stops.

7. Repetitive diving is not allowed with less than a 12-hour surface interval.

8. Table 1-23a is the Helium-Oxygen Decompression Table for Exceptional Exposures and should never be used except in cases of extreme operational necessity or in the case of a fouled diver who has exceeded the maximum bottom time allowed by Table 1-23. The use of these schedules for operational dives shall be directed only by the Commanding Officer of the diving facility involved, and he shall assume the responsibility for any mishap which might occur because of their use.

In this handbook Table 1-23 and Table 1-23a associated schedules are printed on the same page with the EXCEPTIONAL EXPOSURE Schedules shown in red.

SELECTION OF CORRECT HELIUM-OXYGEN DECOMPRESSION TABLE:

Any of the following three procedures may be used to determine the correct Helium-Oxygen Decompression Table to be used.

Procedure No. 1

Use of $He\text{-}O_2$ Decompression Table Selector–

a. Dial depth of dive.

b. Find correct table under the exact or next lesser oxygen percentage in breathing mix.

c. Maximum allowable bottom time for normal operations in accordance with Table 1-16a is shown below the table number.

Alternate Procedure No. 2

Use of Table of $He\text{-}O_2$ Partial Pressures (Table 1-22)

a. Enter Table 1-22 on left margin using the exact or next greater depth.

b. Select oxygen percent column with the exact or next lesser oxygen in mix.

c. At intersection read exact or next greater partial pressure table to be used.

Alternate Procedure No. 3

Computation of Correct Table

Formula: PP (AOG)= (D + 33) x (1.00 – (O_2 – 0.02))

Where: PP (AOG)= partial pressure in feet of all other gases except oxygen (Table Designation)

D = depth of dive in feet of seawater
O_2 = decimal equivalent of oxygen percentage
0.02 = an assured loss of 2% O_2 in helmet

Example: To dive to 290 ft. with an 84% He-16% O_2 mixture for 12 minutes–

1. Select Table

Procedure No. 1
D = 290
PP = 280
Max. Allowable
Bottom Time = 30 min.

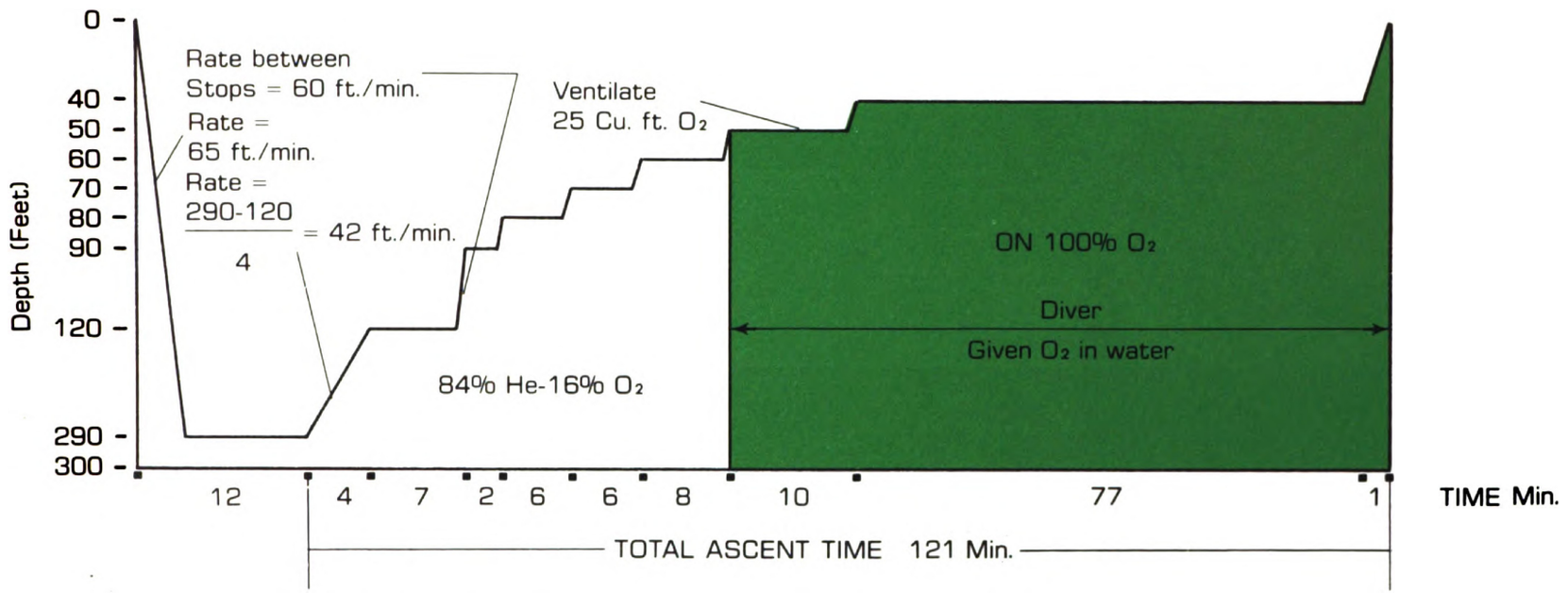
or

Procedure No. 2
D = 290
PP = 278
Use PP = 280

or

Procedure No. 3
PP = (290 + 33) x (1.00 – (0.16 – 0.02))
P: = 323 x (1.00 – 0.14)
PP = 323 x 0.86
PP = 277.8
Use PP = 280

2. Conduct dive using He-O_2 Decompression Table 1-23, Partial Pressure (280), 20 minute schedule.



HELIUM-OXYGEN DECOMPRESSION WITH OXYGEN SURFACE DECOMPRESSION

It is routine procedure to employ the surface decompression technique with oxygen breathing in helium-oxygen diving as an alternate to complete inwater decompression. This technique improves the comfort and safety of the diver by reducing his time underwater and provides simplified handling of oxygen toxicity problems. A recompression chamber equipped for oxygen breathing is required. **Selection of the correct Helium-Oxygen Decompression Table (Table 1-23) and initial inwater decompression are the same as the instructions for use of the Helium-Oxygen Decompression Tables.** The following changes are made in the final stages of decompression:

A. For Schedules in Which the First Stop is 40 Feet–

1. Upon reaching 40 ft. stop ventilate with 25 cu. ft. of oxygen.
2. Keep diver on O_2 for 10 minutes at 40 feet.
3. Surface diver in 1 minute.*
4. Repressurize diver to 40 feet in recompression chamber.*
5. Have diver breathe O_2 by mask for the full time of the 40 ft. stop.
6. During the last 5 minutes of decompression time, surface the diver at a uniform rate while he continues to breathe oxygen.

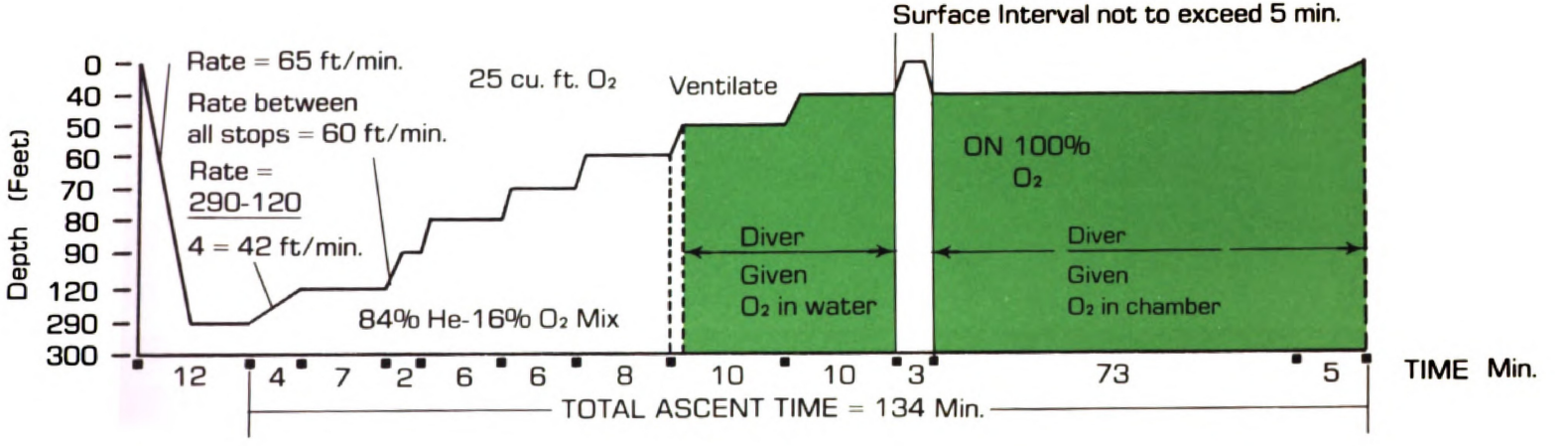
* **Maximum allowable time for steps 3 and 4 is 5 minutes.**

B. For Schedules in Which the First Stop is Deeper than 40 Feet–

1. Upon reaching 50 ft. stop ventilate with 25 cu. ft. of oxygen.
2. Keep diver on O_2 for time of 50 ft. stop.
3. Ascend to 40 ft. stop and remain on oxygen for a length of time equal to that of the 50 ft. stop.
4. Surface diver 1 minute.*
5. Repressurize diver to 40 feet in recompression chamber.*
6. Have diver breathe O_2 by mask for the full time of the 40 ft. stop.
7. During the last 5 minutes of decompression time, surface the diver at a uniform rate while he continues to breathe oxygen.

* **Maximum allowable time for steps 4 and 5 is 5 minutes.**

EXAMPLE: Using the previous example of a dive to 290 ft. with an 84% He-16% O_2 mix for 12 minutes, the 280/20 Table is used. When surface decompressing using oxygen is employed, the dive profile is as follows:



EMERGENCY DECOMPRESSION TABLES

Emergency Decompression Tables are intended to provide alternate decompression schedules when the planned decompression mix cannot be given. Table 1-24 (He-O_2) provides for the use of a helium-oxygen mixture when O_2 is not available. Table 1-25 (Air) provides a decompression procedure for mixed gas diving when neither oxygen nor He-O_2 can be used and air must be substituted.

RECOMPRESSION TREATMENT

Decompression sickness occurring in mixed gas diving is treated in the same way as in air diving (see the Emergency Operating Procedures section for specific instructions).

SPECIALIZED DIVING TABLES

SATURATION DIVING TABLES

Specialized tables for decompression of divers from saturation exposures are included in the handbook. These tables have been developed for specialized operational requirements involving protracted exposure times during which the tissues of the diver's body come to equilibrium with the breathing gas. Special equipment such as underwater habitats or saturation deep diving systems are required to conduct saturation diving operations. This form of diving is relatively new and only modest field experience with these tables has been accumulated. Consequently their use requires the prior authorization of the USN Supervisor of Diving.

SATURATION—EXCURSION DIVING TABLES

These tables are related to the Saturation Diving Tables and the same restrictions apply to their use. The tables provide the safe limiting depth-time excursions that may be performed to depths **GREATER** than the saturation depth. In application they are used for excursions from bottom habitats to lower depths and from a personnel transer capsule (PTC) operating at saturation pressure. The Saturation Excursion Tables are applied using the same type of procedures as employed in regular no-decompression and repetitive diving.

SATURATION ABORT TABLES

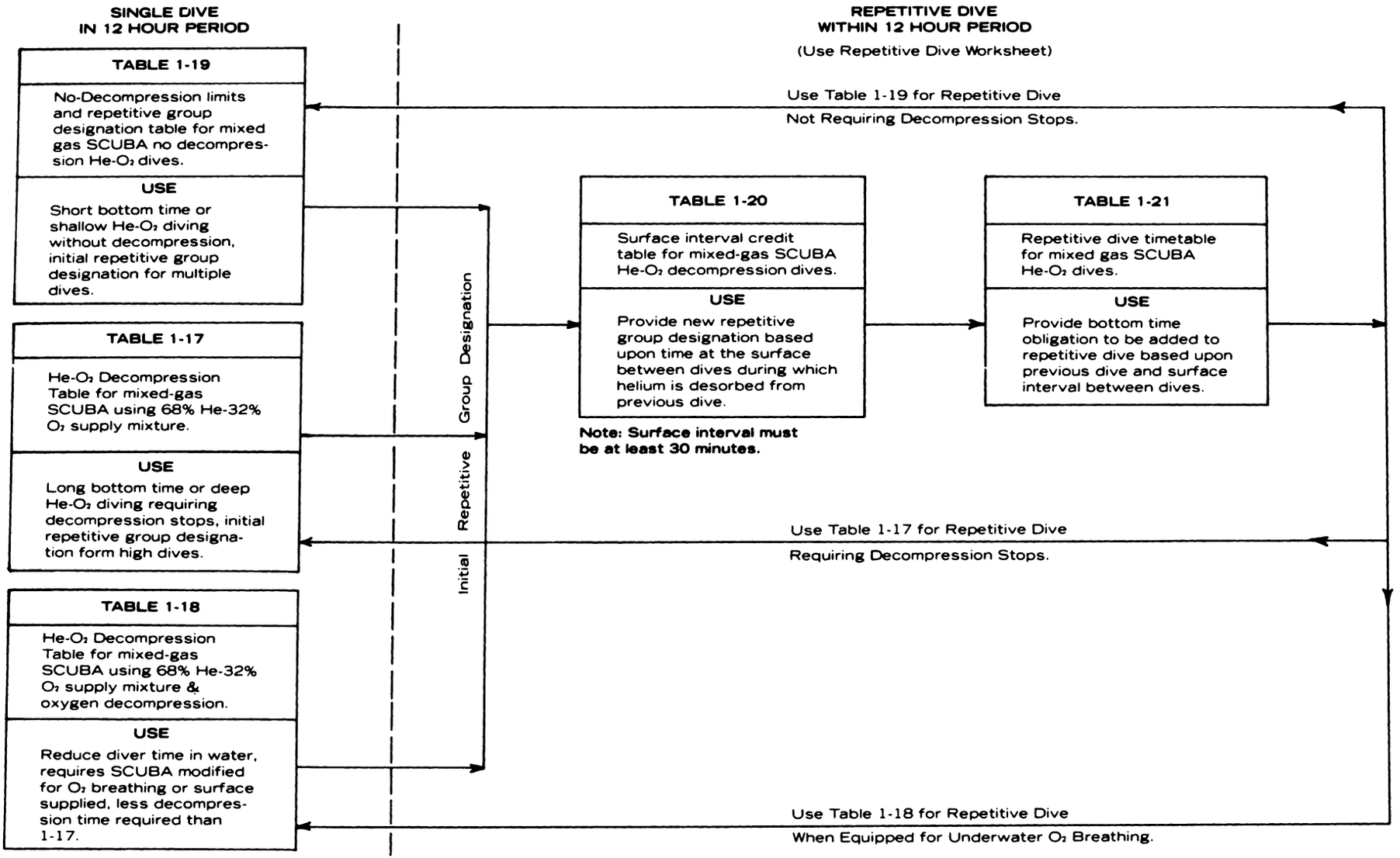
These tables provide alternate decompression schedules for use in saturation diving when the dive must be aborted for emergency or technical reasons prior to the divers becoming completely saturated.

SATURATION DECOMPRESSION TREATMENT TABLES

These treatment tables are included in this section of the handbook because of their unique application to saturation diving. They have been developed to provide a pressure treatment technique for handling decompression sickness during saturation diving operations.

DECOMPRESSION TABLE SELECTOR—MIXED GAS DIVING

MIXED GAS SCUBA



MIXED GAS DEEP SEA DIVING

REPETITIVE DIVING IS NOT ALLOWED WITH LESS THAN A 12-HOUR SURFACE INTERVAL.

Helium-Oxygen Decompression Table Selector

USE

Simplified, direct dial selector for determining appropriate He-O_2 Decompression Table to be used.

TABLE 1-22

Table of He-O_2 Partial Pressures – 40 ft. to 380 ft.

USE

Direct selection of appropriate He-O_2 Decompression Table to be used.

DIRECT CALCULATION

USE

Direct calculation of appropriate He-O_2 Decompression Table to be used based on formula $PP = (D + 33)(1.00 - (O_2 - 0.02))$.

Provides Appropriate Table Designation

TABLE 1-23	TABLE 1-23a
Helium-Oxygen Decompression Table.	Helium-Oxygen Decompression Table for exceptional exposures.
USE Mixed gas diving using deep sea gear, inwater O_2 decompression.	**USE** Emergency or exceptional situations justifying additional risks associated with high partial pressures of oxygen.

Note: TABLE 1-23a is combined with TABLE 1-23 and printed in red.

TABLE 1-23	TABLE 1-23a
Helium-Oxygen Decompression Table with oxygen surface decompression.	Helium-Oxygen Decompression Table with oxygen surface decompression for exceptional exposures.
USE Alternate to complete inwater decompression of diver, improve contact and safety of diver, longer decompression time than direct use of Table 1-23.	**USE** Same procedure as used at left with Table 1-23a, emergency or exceptional situations.

TABLE 1-24

EMERGENCY TABLE (He-O_2)

USE

Use this Table for He-O_2 diving when oxygen cannot be used for decompression.

TABLE 1-25

EMERGENCY TABLE (AIR)

USE

Use this Table for He-O_2 diving when neither oxygen nor He-O_2 is available.

TABLE 1-17 HELIUM-OXYGEN DECOMPRESSION TABLE FOR MIXED-GAS SCUBA USING 68% HELIUM-32% OXYGEN SUPPLY MIXTURE

SPECIAL INSTRUCTIONS

This Table for use only with semi closed-circuit apparatus.

The Standard Supply Mixture (68% He-32% O_2) can be used to a maximum depth of 200 feet for 30 minutes.

The Alternate Gas Mixture (60% He-40% O_2) is limited to a maximum depth of 80 feet and is intended mainly for use in depths less than 50 feet.

Rate of descent should not exceed 75 feet/minute.

Rate of ascent from bottom and between stops should be 60 feet/minute.

Depth (ft)	Bottom time (min)	Time to first stop (min:sec)	Decompression stops (feet) 50	40	30	20	10	Total ascent time (min:sec)	Repetitive group
40	260						0	0:40	L
50	180						0	0:50	L
	200	0:40					20	20:50	L
60	130						0	1:00	L
	150	0:50					20	21:00	L
	170	0:50					35	36:00	L
70	85						0	1:10	J
	100	1:00					15	16:10	K
	115	1:00					25	26:10	L
	130	1:00					40	41:10	L
80	60						0	1:20	I
	70	1:00				5	10	16:20	J
	80	1:00				10	15	26:20	K
	90	1:00				10	25	36:20	K
	100	1:00				10	35	46:20	K
90	45						0	1:30	H
	60	1:10				5	10	16:30	J
	70	1:10				5	20	26:30	K
	85	1:10				10	30	41:30	L

			50	40	30	20	10		
100	35						0	1:40	G
	50	1:20				5	15	21:40	J
	60	1:20				10	20	31:40	K
	70	1:10			5	15	25	46:40	K
110	30						0	1:50	G
	40	1:30				5	10	16:50	H
	50	1:30				10	20	31:50	J
	65	1:20			5	15	25	46:50	L
120	25						0	2:00	G
	35	1:40				5	10	17:00	I
	45	1:30			5	10	15	32:00	K
	55	1:30			10	15	20	47:00	L
130	20						0	2:10	F
	30	1:50				5	10	17:10	I
	40	1:40			5	10	15	32:10	J
	50	1:30		5	5	15	20	47:10	L
140	15						0	2:20	E
	25	2:00				5	10	17:20	G
	35	1:50			5	10	20	37:20	J
	45	1:40		5	5	15	25	52:20	K
150	15						0	2:30	E
	20	2:10				5	10	17:30	G
	30	2:00			5	10	15	32:30	J
	40	1:50		5	10	15	20	52:30	K
160	10						0	2:40	E
	20	2:10			5	5	10	22:40	G
	35	2:00		5	10	10	20	47:40	K
170	10						0	2:50	E
	20	2:20			5	5	10	22:50	H
	35	2:10		5	10	15	20	52:50	K
180	5						0	3:00	C
	10	2:40				5	10	18:00	E
	20	2:20		5	5	10	10	33:00	H
	30	2:20		5	10	15	20	53:00	K

TABLE 1-17 HELIUM-OXYGEN DECOMPRESSION TABLE FOR MIXED-GAS SCUBA USING 68 TO 32 PERCENT HELIUM-OXYGEN SUPPLY MIXTURE

	Bottom time (min)	Time to first stop (min:sec)	Decompression stops (feet) 50	40	30	20	10	Total ascent time (min:sec)	Repetitive group
190	10	2:50				5	10	18:10	E
	20	2:30		5	5	10	20	43:10	H
	30	2:20	5	5	10	15	25	63:10	K
200	10	3:00				5	15	23:20	F
	20	2:40		5	5	10	20	43:20	I
	30	2:30	5	5	10	15	35	73:20	K

TABLE 1-18 HELIUM-OXYGEN DECOMPRESSION TABLE FOR MIXED-GAS SCUBA USING 68% HELIUM-32% OXYGEN SUPPLY MIXTURE AND OXYGEN DECOMPRESSION

SPECIAL INSTRUCTIONS

This Table allows for oxygen decompression from helium-oxygen mixed-gas dives and provides significant savings in decompression time as compared with Table 1-17.

This Table can only be used with semi closed-circuit apparatus modified with Oxygen Cylinder and Injection System or by supplying the diver on a descending line with surface-supplied oxygen delivered to a demand regulator at the required decompression depth.

The first oxygen stop is at 20 or 30 feet.

Two (2) minutes are provided in the Table to secure the Helium-Oxygen Injection System and purge the breathing bag thoroughly three (3) times with Oxygen at the first oxygen stop.

Decompression time at the first oxygen stop does not start until after the required two (2) minutes for oxygen purging have elapsed.

Depth (ft)	Time (min)	Decompression stops (min) He-O_2 50 feet	He-O_2 40 feet	Oxygen 30 feet	Oxygen 20 feet	Repetitive group
60	170				20	L
70	115				15	L
	130				25	L
80	80				15	K
	90				20	K
	100				25	K
90	70				15	K
	85				25	L
100	50				15	J
	60				20	K
	70			5	20	K
110	50				15	J
	65			5	20	L
120	45			5	15	K
	55			10	20	L
130	40			5	15	J
	50		5	5	20	L

ALLOW 2 MINUTES TO COMPLETE BAG PURGE TO OXYGEN

Depth (ft)	Time (min)	Decompression stops (min) He-O_2 50 feet	He-O_2 40 feet	Oxygen 30 feet	Oxygen 20 feet	Repetitive group
140	35			5	15	J
	45		5	5	20	K
150	30			5	15	J
	40		5	10	20	K
160	20			5	10	G
	35		5	10	20	K
170	20			5	10	H
	35		5	10	20	K
180	20			5	10	H
	30		5	10	20	K
190	20			5	15	H
	30	5	5	10	20	K
200	20		5	5	20	I
	30	5	5	10	25	K

ALLOW 2 MINUTES TO COMPLETE BAG PURGE TO OXYGEN

TABLE 1-19 NO-DECOMPRESSION LIMITS AND REPETITIVE GROUP DESIGNATION MIXED-GAS SCUBA NO-DECOMPRESSION TABLE FOR HELIUM-OXYGEN DIVES

SPECIAL INSTRUCTIONS

This Table for use only with Mixed Gas Scuba (68% He-32% O_2).

No-Decompression limits column: allowable maximum bottom time which permits surfacing directly at 60 feet/minute with no decompression stops.

For longer bottom times use the Helium-Oxygen Decompression Table for Mixed Gas Scuba Table 1-17.

Repetitive Group Designation Table: time periods in each vertical column are the maximum exposures at various depths during which a diver will remain within the group listed at the head of the column.

Repetitive Group Designation: Enter Table on exact or next greater depth than exposure and select exposure time exact or next greater than actual exposure time. Read group designation (letter) at top of column for next dive.

Exposure times for depths less than 40 feet are listed up to 12 hours although this is considered beyond field requirements for this Table.

EXAMPLE

A Dive to 42 Feet for 45 minutes:

1. Select next greater depth = 50 ft.
2. Select next greater exposure time than 45 minutes = 55 minutes.
3. Read Repetitive Group Designation at top of column = Group E.

TABLE 1-19 NO-DECOMPRESSION LIMITS AND REPETITIVE GROUP DESIGNATION TABLE FOR NO-DECOMPRESSION HELIUM-OXYGEN DIVES

Depth (ft)	No-decompression limits (min)	Repetitive groups (He-O_2 dives)											
		A	B	C	D	E	F	G	H	I	J	K	L
10		70	190	720									
20		25	60	95	145	215	335	720					
30		15	35	60	80	110	145	185	245	335	525	720	
40	260	10	25	40	55	70	90	110	140	165	200	245	260
50	180	10	20	30	40	55	70	85	100	120	140	160	180
60	130	5	15	25	35	45	55	65	75	90	105	120	130
70	85	5	10	20	30	35	45	55	65	75	85		
80	60	5	10	15	25	30	40	45	55	60			
90	45	5	10	15	20	25	35	40	45				
100	35	5	10	15	20	25	30	35					
110	30	5	9	12	15	20	25	30					
120	25	5	8	10	15	20	22	25					
130	20		5	10	15	17	20						
140	15		5	10	12	15							
150	15		5	10	12	15							
160	10		5	6	8	10							
170	10		5	6	8	10							
180	5			5									

TABLE 1-20 SURFACE INTERVAL CREDIT TABLE FOR MIXED-GAS SCUBA HELIUM-OXYGEN DECOMPRESSION DIVES

SPECIAL INSTRUCTIONS

Surface interval time in the Table is in Hours and Minutes (1:30 = 1 hour & 30 min.).

Surface interval must be at least 30 min.

Repetitive group designation after surface interval. Enter Table on diagonal slope using designation from previous dive. Read horizontally until the actual surface interval is exactly between interval shown in Table. Read new group designation at top of column.

Dives following surface intervals of more than 12 hours are not repetitive dives. Use actual bottom times in the Helium-Oxygen Decompression Tables to compute decompression for such dives.

EXAMPLE

Find new group designation after dive to 110 feet for 30 minutes and a time on the surface of 1 hour and 30 minutes.

1. Previous repetitive group from last column of 110/30 schedule of the Helium-Oxygen Decompression Tables = G (Table 1-17).
2. Locate "G" in diagonal column.
3. Follow Table across horizontally.
4. The 1 hr. 30 min. interval lies between the times 1:01 and 1:40.
5. Diver has lost sufficient inert gas to place him in group at top of vertical column = E.

TABLE 1-20 SURFACE INTERVAL CREDIT TABLE FOR HELIUM-OXYGEN DECOMPRESSION DIVES

[Repetitive group at the end of the surface interval (He-O_2 dives)]

Repetitive group at the beginning of the surface interval from previous dive

	L	K	J	I	H	G	F	E	D	C	B	A
L	0:00 0:30	0:31 0:40	0:41 0:50	0:51 1:20	1:21 1:40	1:41 2:00	2:01 2:30	2:31 3:10	3:11 4:00	4:01 5:10	5:11 7:10	7:11 12:00*
K	0:00 0:30	0:31 0:40	0:41 1:00	1:01 1:20	1:21 1:50	1:51 2:20	2:21 3:00	3:01 3:50	3:51 5:00	5:01 7:00	7:01 12:00*	
J	0:00 0:30	0:31 0:40	0:41 1:00	1:01 1:30	1:31 2:00	2:01 2:40	2:41 3:30	3:31 4:40	4:41 6:40	6:41 12:00*		
I	0:00 0:30	0:31 0:50	0:51 1:20	1:21 1:50	2:21 2:20	2:21 3:10	3:11 4:20	4:21 6:20	6:21 12:00*			
H	0:00 0:30	0:31 0:50	0:51 1:30	1:31 2:00	2:01 2:50	2:51 4:00	4:01 6:00	6:01 12:00*				
G	0:00 0:30	0:31 1:00	1:01 1:40	1:41 2:30	2:31 3:40	3:41 5:40	5:41 12:00*					
F	0:00 0:35	0:36 1:10	1:11 2:00	2:01 3:10	3:11 5:10	5:11 12:00*						
E	0:00 0:40	0:41 1:30	1:31 2:40	2:41 4:40	4:41 12:00*							
D	0:00 0:50	0:51 2:00	2:01 4:00	4:01 12:00*								
C	0:00 1:20	1:21 3:10	3:11 12:00*									
B	0:00 2:00	2:01 12:00*										
A	0:00 12:00*											

* Dives following surface intervals of more than 12 hours are not repetitive dives. Use actual bottom times in the Helium-Oxygen Decompression Tables to compute decompression for such dives.

TABLE 1-21 REPETITIVE DIVE TIMETABLE FOR MIXED-GAS SCUBA HELIUM-OXYGEN DIVES

SPECIAL INSTRUCTIONS

Bottom times listed in this Table are called **Residual Helium Times.**

Residual Helium Time is the time a diver is to consider he has already spent on bottom when a repetitive dive is started to a specific depth.

To find bottom time to be added to schedule for repetitive dive:

Enter Table horizontally with repetitive group from **Surface Interval Credit Table** (Table 1-20). Read directly bottom time to be added to the repetitive dive in the depth column for that dive.

EXAMPLE

The group designation from the Surface Interval Credit Table from a previous dive is "H." How much bottom time must be added (Residual Helium Time) for a repetitive dive to 110 feet?

1. Enter Table horizontally at "H."
2. Read in 110 foot depth column Residual Helium Time to be added = 39 minutes.
3. The Tables shows that one must start a dive to 110 feet as though he had already been on the bottom 39 minutes.
4. Use Helium-Oxygen Decompression Table 1-17 or 1-18 or No-Decompression Table to determine dive schedule for repetitive dive.

Repetitive groups	Repetitive dive depth (ft) (He-O_2 dives)																
	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
A	13	10	8	7	6	6	5	5	4	4	4	4	3	3	3	3	3
B	26	21	17	14	13	11	10	9	8	8	7	7	6	6	6	5	5
C	40	32	26	22	19	17	15	14	13	12	11	10	9	9	8	8	8
D	56	44	35	30	26	23	20	19	17	15	14	13	13	12	11	11	10
E	74	57	45	38	33	29	26	23	21	19	18	17	16	15	14	13	13
F	93	71	56	47	40	35	31	28	26	24	22	20	19	18	17	16	15
G	115	86	67	56	47	42	37	33	30	28	26	24	22	21	20	19	18
H	139	102	79	66	55	48	43	39	35	32	29	28	26	24	22	21	20
I	168	120	92	76	64	56	49	44	40	37	33	31	29	27	26	24	23
J	203	141	105	87	72	63	55	49	45	41	37	35	32	31	28	27	25
K	248	165	120	98	80	71	61	55	49	45	42	39	36	34	32	30	28
L	305	191	137	111	91	79	68	61	55	50	46	43	40	37	35	33	31

HELIUM-OXYGEN DECOMPRESSION TABLE SELECTOR

30 FEET TO 205 FEET (See other side for 205 FEET to 380 FEET)

USE OF THE SELECTOR

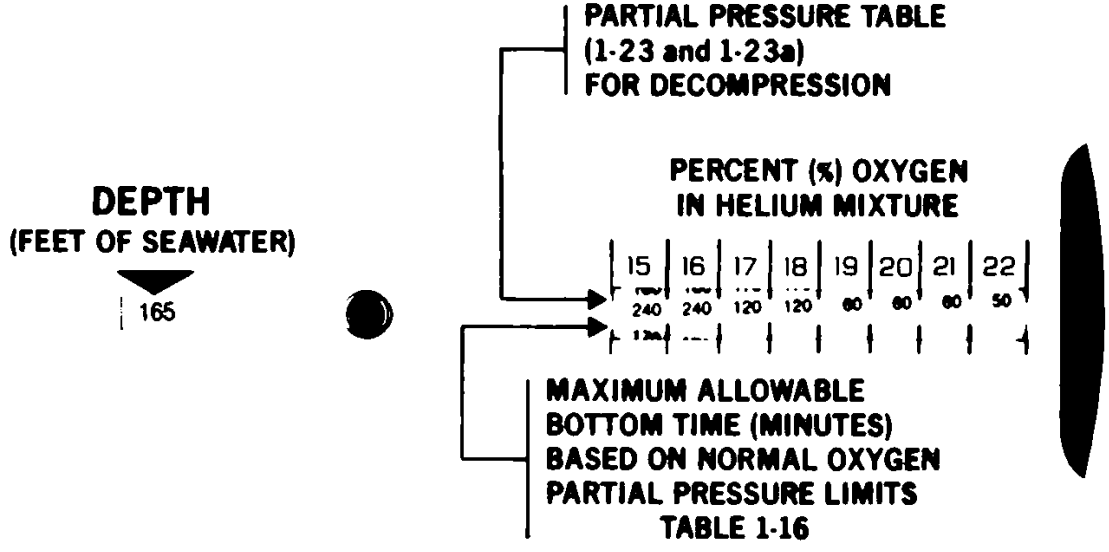
- Turn dial to exact or next greater Depth of Dive.
- Find correct Partial Pressure Table for exact or next lesser % O_2 in Gas Mixed Used.
- Read Maximum Allowable Bottom Time for Mixture, Depth, and Table to stay within Normal O_2 Toxicity Limits.
- Read correct Decompression Schedule for Actual Bottom Time of Dive on Partial Pressure Table indicated.

EXAMPLE

Dive to 183 feet on 16% O_2 for 22 minutes.
Depth=185 feet P.P. Table No.=190
Decompression Schedule (Table 1-23)=190/30

SPECIAL NOTES

- THESE TABLES ARE PRIMARILY INTENDED FOR USE WITH He–O_2 DEEP SEA GEAR.
- DIVES BELOW 300 FEET REQUIRE THE PRIOR APPROVAL OF THE U.S.N. SUPERVISOR OF DIVING.
- 16% O_2 IS THE MINIMUM OXYGEN CONTENT THAT WILL PERMIT SAFE BREATHING ON THE SURFACE. USE OF MIXTURES HAVING LESS THAN 16% O_2 SHOULD BE USED ONLY UNDER EMERGENCY CIRCUMSTANCES.



NO NUMBER=NO TIME LIMITATION

EXC=EXCEPTIONAL EXPOSURE. CONSULT APPROPRIATE P.P. TABLE FOR TIME LIMITS

*** =EXCEPTIONAL EXPOSURE BEYOND OXYGEN PARTIAL PRESSURE LIMITS-TABLE 1-16a. USE WITH THESE O_2 MIXTURES IS NOT RECOMMENDED.**

HELIUM-OXYGEN DECOMPRESSION TABLE SELECTOR

205 FEET TO 380 FEET (See other side for 30 FEET to 205 FEET)

USE OF THE SELECTOR

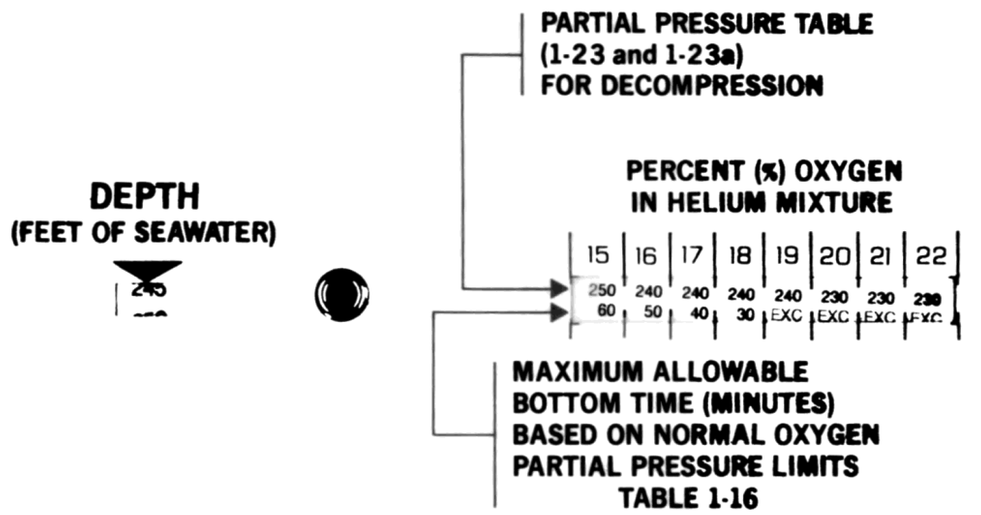
- Turn dial to exact or next greater Depth of Dive.
- Find correct Partial Pressure Table for exact or next lesser % O_2 in Gas Mixed Used.
- Read Maximum Allowable Bottom Time for Mixture, Depth, and Table to stay within Normal O_2 Toxicity Limits.
- Read correct Decompression Schedule for Actual Bottom Time of Dive on Partial Pressure Table indicated.

EXAMPLE

Dive to 262 feet on 17% O_2 for 18 minutes.
Depth=265 feet P.P. Table No.=260
Decompression Schedule (Table 1-23)=260/20

SPECIAL NOTES

- THESE TABLES ARE PRIMARILY INTENDED FOR USE WITH He–O_2 DEEP SEA GEAR.
- DIVES BELOW 300 FEET REQUIRE THE PRIOR APPROVAL OF THE U.S.N. SUPERVISOR OF DIVING.
- 16% O_2 IS THE MINIMUM OXYGEN CONTENT THAT WILL PERMIT SAFE BREATHING ON THE SURFACE. USE OF MIXTURES HAVING LESS THAN 16% O_2 SHOULD BE USED ONLY UNDER EMERGENCY CIRCUMSTANCES.



NO NUMBER=NO TIME LIMITATION

EXC=EXCEPTIONAL EXPOSURE. CONSULT APPROPRIATE P.P. TABLE FOR TIME LIMITS

*** =EXCEPTIONAL EXPOSURE BEYOND OXYGEN PARTIAL PRESSURE LIMITS-TABLE 1-16a. USE WITH THESE O_2 MIXTURES IS NOT RECOMMENDED.**

TABLE 1-22 TABLE OF HELIUM-OXYGEN PARTIAL PRESSURES—40 TO 380 FEET (Enter this table—select partial pressures)

(FORMERLY TABLE 1-12, 1963 DIVING MANUAL)

Depth (feet)	Oxygen percent												
	15	16	17	19	21	23	25	30	35	40	45	50	55
40	64	63	63	61	60	58	57	[*]	[*]	[*]	[*]	[*]	[*]
50	73	72	71	69	68	66	64	60	56	[*]	[*]	[*]	[*]
60	81	80	80	78	76	74	72	67	63	58	54	[*]	[*]
70	90	89	88	86	84	82	80	75	70	64	59	54	[*]
80	99	98	97	94	92	90	88	82	76	71	65	59	54
90	108	106	105	103	100	98	95	89	83	77	71	64	
100	116	115	114	111	108	106	103	96	90	83	76		
110	125	123	122	119	116	113	111	103	96	89	82		
120	134	132	131	127	124	121	118	111	103	95			
130	142	141	139	136	133	129	126	118	110	102			
140	151	149	148	144	141	137	134	125	116				
150	160	158	156	152	149	145	141	132	123				
160	168	166	165	161	157	155	149	139					
170	177	175	173	169	165	161	157	147					
180	186	184	182	177	173	169	165	154					
190	195	192	190	186	181	177	172						
200	203	201	199	194	189	185	180						
210	212	209	207	202	197	192	188						
220	221	218	216	210	205	200	195						
230	229	227	224	219	214	203	203						
240	238	235	233	227	222	216							
250	247	244	241	235	230	224							
260	255	252	250	244	238								
270	264	261	258	252	246								
280	273	270	267	260	254								
290	282	278	275	269									
300	290	287	284	277									
310	299	295	292	285									
320	308	304	301										
330	316	313	309										
340	325	321	318										
350	334	330	326										
360	342	338											
370	351	347											
380	360	356											

Numbers in red indicate exposures which exceed the limit for a 30 minute exposure at 1.6 atmospheres PO_2.

*No-decompression

$$\text{Cutoff depth for oxygen} = \frac{52.8}{\text{Oxygen percent}} - 33$$

$$\frac{52.8}{D + 33} \times 100 = \text{maximum oxygen percent}$$

$$\frac{D + 33 \times \text{oxygen percent}}{33} = \text{Effective atmospheres of oxygen}$$

$$PP = (D + 33) \times [1.00 - (\text{Decimal equivalent of } O_2\% - 0.02)]$$

16 percent is considered the minimum oxygen percentage for surface breathing. The Partial Pressure Tables are not designed for shifting to lower percentages of oxygen during the dive. Therefore, those Partial Pressure Tables requiring a lower percent of oxygen are for emergency use only.

TABLE 1-23 & 1-23a HELIUM-OXYGEN DECOMPRESSION TABLE (Normal and Exceptional Exposures)

(FORMERLY TABLE 1-11, 1963 DIVING MANUAL)

SPECIAL INSTRUCTIONS

TABLE SELECTION

Select proper partial pressure table by using one of the following procedures discussed on pages 138 and 139–

IN-WATER DECOMPRESSION

1. Rate of ascent to first stop =

$$\frac{\text{Bottom Depth} - \text{Depth of First Stop}}{\text{Time to First Stop}}$$

2. Rate of ascent between stops is 60 ft./min.
3. Switch to O_2 and ventilate 25 scf at 50 ft. or 40 ft. if there is no 50 ft. stop. Ventilation time is included in stop time.
4. Remain on O_2 for time of 50 ft. and 40 ft. stops.
5. Ascend on O_2 to surface at a uniform rate during the last minute of the 40 ft. stop.

SURFACE DECOMPRESSION

For schedules in which the First Stop is 40 ft.:

1. Ventilate with O_2 as above.
2. Remain on O_2 for 10 minutes at 40 ft.
3. Surface diver in 1 minute.*
4. Repressurize diver to 40 ft. in recompression chamber with air.*
5. Diver breathes O_2 by mask for full time of 40 ft stop.
6. During last 5 minutes of decompression time surface diver at uniform rate while breathing O_2.

For Schedules in which the first stop is 50 ft.:

1. Ventilate with O_2 and stay at 50 ft. for full stop time.
2. Ascend to 40 ft. stop and stay at 40 ft. for time of 50 ft. stop.
3. Surface in 1 minute and follow procedure above.

*Maximum allowable time for steps 4 and 5 is 5 minutes.

PARTIAL PRESSURE	BOTTOM TIME (MIN.)	TIME TO FIRST STOP (MIN.)	Decompression Stops (Feet) 180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	TOTAL ASCENT TIME (MIN.)
60	10	4															0	4
	20	4															0	4
	30	4															0	4
	40	4															0	4
	60	4															0	4
	80	4															6	8
	100	2															7	9
	120	2															9	11
	240	2															13	15

			180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
70	10																6	9
	20																7	10
	30																9	12
	40																10	13
	60																15	18
	80																17	20
	100	3															22	25
	120																25	28
	140																27	30
	160																29	32
	180																31	34
	200																31	34
	220																33	36
	240																33	36
80	10																6	9
	20																10	13
	30																13	16
	40																17	20
	60																24	27
	80																32	35
	100	3															40	43
	120																42	45
	140																45	48
	160																47	50
	180																48	51
	200																48	51
	220																48	51
	240																50	53
90	10																8	11
	20																15	18
	30																18	21
	40																23	26
	60																35	38
	80																45	48
	100	3															50	53
	120																55	58
	140																58	61
	160																60	63
	180																60	63
	200																62	65
	220																62	65
	240																63	66

TABLE 1-23 HELIUM-OXYGEN DECOMPRESSION TABLE

PARTIAL PRESSURE	BOTTOM TIME (MIN.)	TIME TO FIRST STOP (MIN.)	Decompression Stops (Feet) 180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	TOTAL ASCENT TIME (MIN.)
100	10	3															10	13
	20																17	20
	30																24	27
	40																31	34
	60																47	50
	80																56	59
	100																63	66
	120																67	70
	140																70	73
	160																72	75
	180																73	76
	200																73	76
	220																73	76
	240																75	78
110	10	3															12	15
	20																21	24
	30																31	34
	40																39	42
	60																56	59
	80																67	70
	100																75	78
	120																78	81
	140																81	84
	160																83	86
	180																84	87
	200																84	87
	220																85	88
	240																86	89

			180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
120	10																14	17
	20																25	28
	30																36	39
	40																47	50
	60																66	69
	80																77	80
	100																84	87
	120	3															87	90
	140																90	93
	160																92	95
	180																93	96
	200																93	96
	220																95	98
	240																97	100
130	10															0	16	19
	20															0	29	32
	30															0	42	45
	40															0	53	56
	60															0	73	76
	80															0	86	89
	100															0	92	95
	120	3														0	96	99
	140															0	99	102
	160															10	92	105
	180															10	93	106
	200															10	94	107
	220															10	95	108
	240															10	96	109
140	10															0	19	22
	20															0	34	37
	30															0	49	52
	40															0	62	65
	60															0	82	85
	80															0	94	97
	100															0	99	102
	120	3														10	97	110
	140															10	98	111
	160															10	99	112
	180															12	99	114
	200															13	99	115
	220															14	99	116
	240															15	99	117

TABLE 1-23 HELIUM-OXYGEN DECOMPRESSION TABLE and
TABLE 1-23a FOR EXCEPTIONAL EXPOSURES

PARTIAL PRESSURE	BOTTOM TIME (MIN.)	TIME TO FIRST STOP (MIN.)	Decompression Stops (Feet) 180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	TOTAL ASCENT TIME (MIN.)
150	10														0	10	11	24
	20														0	10	28	41
	30														0	10	45	58
	40														7	10	59	79
	60														7	10	78	98
	80														7	10	90	110
	100	3													7	10	96	116
	120														7	11	98	119
	140														7	13	99	122
	160														8	15	99	125
	180														9	15	99	126
	200														10	16	99	128
	220														11	16	99	129
	240														12	16	99	130
160	10													0	0	10	12	25
	20													0	7	10	33	53
	30													0	7	10	50	70
	40													0	7	10	65	85
	60													0	7	10	84	104
	80													0	7	10	96	116
	100	3												0	7	13	99	122
	120													0	9	16	99	127
	140													0	15	16	99	133
	160													0	18	16	99	136
	180													0	20	16	99	138
	200													0	22	16	99	140
	220													0	23	16	99	141
	240													7	19	16	99	144

170

10		0	7	10	15	35
20		0	7	10	36	56
30		0	7	10	55	75
40		0	7	10	70	90
60		7	6	10	83	109
80		7	9	10	98	127
100	3	7	13	14	98	135
120		7	17	16	99	142
140		8	21	16	99	147
160		11	22	16	99	151
180		11	23	16	99	152
200		12	23	16	99	153
220		14	23	16	99	155
240		16	23	16	99	157

180

10		0	7	0	10	17	37
20		0	7	0	10	41	61
30		0	7	1	10	62	83
40		0	7	4	10	77	101
60		0	7	10	10	92	122
80		0	9	14	13	98	137
100	3	7	5	18	15	99	147
120		7	9	21	16	99	155
140		7	11	22	16	99	158
160		7	15	23	16	99	163
180		7	17	23	16	99	165
200		7	19	23	16	99	167
220		7	21	23	16	99	169
240		7	23	23	16	99	171

190

10		0	7	0	10	20	41
20		0	7	0	10	44	65
30		0	7	4	10	67	92
40		7	0	8	10	81	110
60		7	5	11	10	96	133
80		7	9	15	15	99	149
100	4	7	13	19	16	99	158
120		7	17	23	16	99	166
140		9	19	23	16	99	170
160		11	20	23	16	99	173
180		13	21	23	16	99	176
200		14	22	23	16	99	178
220		15	23	23	16	99	180
240		17	23	23	16	99	182

TABLE 1-23 HELIUM-OXYGEN DECOMPRESSION TABLE and
TABLE 1-23a FOR EXCEPTIONAL EXPOSURES

PARTIAL PRESSURE	BOTTOM TIME (MIN.)	TIME TO FIRST STOP (MIN.)	Decompression Stops (Feet) 180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	TOTAL ASCENT TIME (MIN.)
200	10											0	0	7	0	10	22	43
	20											0	7	0	2	10	50	73
	30											0	7	0	7	10	69	97
	40											0	7	4	9	10	84	118
	60											0	7	9	13	12	93	138
	80											7	3	13	18	15	99	159
	100	4										7	6	16	21	16	99	169
	120											7	8	20	23	16	99	177
	140											7	11	21	23	16	99	181
	160											7	15	23	23	16	99	187
	180											7	17	23	23	16	99	189
	200											7	18	23	23	16	99	190
	220											7	20	23	23	16	99	192
	240											8	20	23	23	16	99	193
210	10											0	7	0	0	10	25	46
	20											0	7	0	4	10	53	78
	30											7	0	3	7	10	74	105
	40											7	0	7	10	10	86	124
	60											7	4	10	14	13	98	150
	80											7	8	14	18	16	99	166
	100	4										7	12	17	23	16	99	178
	120											8	15	21	23	16	99	186
	140											10	17	21	23	16	99	190
	160											12	17	22	23	16	99	193
	180											14	18	22	23	16	99	196
	200											16	18	23	23	16	99	199
	220											17	19	23	23	16	99	201
	240											18	20	23	23	16	99	203

			180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
220	10										0	0	7	0	0	10	28	49
	20										0	7	0	1	6	10	57	85
	30										0	7	0	6	7	10	79	113
	40										0	7	3	9	10	10	90	133
	60										7	0	9	11	17	13	98	159
	80										7	3	11	15	20	13	99	172
	100	4									7	6	14	19	23	16	99	188
	120										7	8	18	23	23	16	99	198
	140										7	11	18	23	23	16	99	201
	160										7	14	19	23	23	16	99	205
	180										7	15	20	23	23	16	99	207
	200										7	16	20	23	23	16	99	208
	220										8	17	20	23	23	16	99	210
	240										9	19	20	23	23	16	99	213
230	10										0	0	7	0	2	10	30	53
	20										0	7	0	3	7	10	61	92
	30										0	7	2	6	9	10	81	119
	40										7	0	6	9	11	10	93	140
	60										7	4	9	12	18	14	99	167
	80									0	7	8	12	17	21	16	99	184
	100	4								0	7	12	15	20	23	16	99	196
	120									0	8	14	19	23	23	16	99	206
	140									0	10	16	20	23	23	16	99	211
	160									7	6	18	20	23	23	16	99	216
	180									7	7	19	20	23	23	16	99	218
	200									7	9	19	20	23	23	16	99	220
	220									7	11	19	20	23	23	16	99	222
	240									7	13	19	20	23	23	16	99	224
240	10										0	0	7	0	0	3	10	33	57
	20										0	7	0	1	4	7	10	65	98
	30										0	7	0	5	7	10	10	85	128
	40										7	0	3	7	9	13	11	95	149
	60										7	0	8	10	14	18	15	99	175
	80										7	3	10	14	18	23	16	99	194
	100	4									7	6	12	17	23	23	16	99	207
	120										7	7	16	19	23	23	16	99	214
	140										7	11	16	20	23	23	16	99	219
	160										7	13	19	20	23	23	16	99	224
	180										8	15	19	20	23	23	16	99	227
	200										8	17	19	20	23	23	16	99	229
	220										9	17	19	20	23	23	16	99	230
	240										11	17	19	20	23	23	16	99	232

TABLE 1-23 HELIUM-OXYGEN DECOMPRESSION TABLE and
TABLE 1-23a FOR EXCEPTIONAL EXPOSURES

PARTIAL PRESSURE	BOTTOM TIME (MIN.)	TIME TO FIRST STOP (MIN.)	Decompression Stops (Feet) 180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	TOTAL ASCENT TIME (MIN.)
250	10									0	7	0	0	2	4	10	35	62
	20									0	7	0	2	5	7	10	68	103
	30									7	0	2	6	7	10	10	87	133
	40									7	0	5	8	9	14	12	96	155
	60								0	7	4	8	11	14	19	16	99	182
	80								0	7	7	11	16	18	23	16	99	201
	100	4							0	7	10	14	19	23	23	16	99	215
	120								7	3	12	17	19	23	23	16	99	223
	140								7	4	15	18	19	23	23	16	99	228
	160								7	7	16	19	19	23	23	16	99	233
	180								7	9	17	19	20	23	23	16	99	237
	200								7	11	17	19	20	23	23	16	99	239
	220								7	12	17	19	20	23	23	16	99	240
	240								7	13	17	19	20	23	23	16	99	241
260	10									0	7	0	0	2	4	10	37	64
	20									7	0	0	3	7	7	10	70	108
	30									7	0	4	6	8	10	10	89	138
	40									7	2	5	9	9	14	13	96	159
	60								7	0	7	9	12	16	21	16	99	191
	80	4							7	3	9	13	15	21	23	16	99	210
	100								7	6	11	14	19	23	23	16	99	222
	120								7	8	13	19	20	23	23	16	99	232
	140								7	11	15	19	20	23	23	16	99	237
	160								8	13	17	19	20	23	23	16	99	242
	180								9	14	17	19	20	23	23	16	99	244
	200								10	16	17	19	20	23	23	16	99	247
	220								11	16	17	19	20	23	23	16	99	248
	240								13	16	17	19	20	23	23	16	99	250

270

		180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
10								0	7	0	0	0	4	4	10	40	69
20								0	7	0	2	4	6	7	10	74	114
30								7	0	2	5	6	9	10	10	92	145
40								7	0	3	8	9	10	15	14	96	166
60							0	7	3	7	10	14	16	21	16	99	197
80							0	7	6	10	13	17	23	23	16	99	218
100	4						7	2	9	13	16	20	23	23	16	99	232
120							7	4	11	14	19	20	23	23	16	99	240
140							7	5	14	15	19	20	23	23	16	99	245
160							7	7	15	17	19	20	23	23	16	99	250
180							7	9	16	17	19	20	23	23	16	99	253
200							7	11	16	17	19	20	23	23	16	99	255
220							7	13	16	17	19	20	23	23	16	99	257
240							7	15	16	17	19	20	23	23	16	99	259

280

		180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
10								0	7	0	0	2	3	4	10	42	72
20								7	0	0	2	6	6	8	10	78	121
30								7	0	3	6	6	9	13	10	93	151
40							7	0	2	5	8	8	12	16	13	98	173
60							7	0	6	8	10	14	19	23	16	99	206
80							7	3	8	11	14	17	23	23	16	99	225
100	4						7	5	11	13	16	20	23	23	16	99	237
120							7	8	12	16	19	20	23	23	16	99	247
140							7	10	16	17	19	20	23	23	16	99	254
160							8	13	16	17	19	20	23	23	16	99	258
180							9	14	16	17	19	20	23	23	16	99	260
200							10	15	16	17	19	20	23	23	16	99	262
220							12	15	16	17	19	20	23	23	16	99	264
240							14	15	16	17	19	20	23	23	16	99	266

290

		180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
10								0	0	7	0	0	3	3	4	10	46	77
20								0	7	0	0	4	6	7	7	10	81	126
30								7	0	1	5	5	9	9	12	10	96	158
40							0	7	0	4	6	8	9	12	17	15	98	180
60							0	7	4	6	8	12	15	18	23	16	99	212
80							7	0	7	9	11	15	17	23	23	16	99	231
100	4						7	2	9	11	15	17	20	23	23	16	99	246
120							7	4	11	13	16	19	20	23	23	16	99	255
140							7	5	13	16	17	19	20	23	23	16	99	262
160							7	8	14	16	17	19	20	23	23	16	99	266
180							7	10	15	16	17	19	20	23	23	16	99	269
200							7	12	15	16	17	19	20	23	23	16	99	271
220							7	13	15	16	17	19	20	23	23	16	99	272
240							7	14	15	16	17	19	20	23	23	16	99	273

TABLE 1-23 HELIUM-OXYGEN DECOMPRESSION TABLE and
TABLE 1-23a FOR EXCEPTIONAL EXPOSURES

PARTIAL PRESSURE	BOTTOM TIME (MIN.)	TIME TO FIRST STOP (MIN.)	Decompression Stops (Feet)															TOTAL ASCENT TIME (MIN.)
			180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
300	10	5				0	0	0	7	0	0	0	4	3	4	10	49	82
	20					0	0	7	0	0	2	6	6	6	9	10	83	134
	30					0	0	7	0	2	5	5	9	9	14	12	94	162
	40					0	0	7	0	5	7	8	11	13	17	15	98	186
	60					0	7	0	6	7	9	12	15	20	23	16	99	219
	80					0	7	2	8	10	12	16	19	23	23	16	99	240
	100					0	7	5	10	12	15	19	20	23	23	16	99	254
	120					0	7	8	11	16	17	19	20	23	23	16	99	264
	140					0	8	9	14	16	17	19	20	23	23	16	99	269
	160					0	8	13	15	16	17	19	20	23	23	16	99	274
	180					7	3	13	15	16	17	19	20	23	23	16	99	276
	200					7	5	14	15	16	17	19	20	23	23	16	99	279
	220					7	6	14	15	16	17	19	20	23	23	16	99	280
	240					7	9	14	15	16	17	19	20	23	23	16	99	283
310	10	5				0	0	0	7	0	0	2	3	3	5	10	52	87
	20					0	0	7	0	0	4	5	6	6	11	10	84	138
	30					0	7	0	0	5	5	7	8	9	14	12	96	168
	40					0	7	0	3	5	8	8	11	13	18	15	99	192
	60					0	7	3	6	7	10	12	18	22	23	16	99	228
	80					7	0	6	9	11	12	16	19	23	23	16	99	246
	100					7	1	9	10	14	17	19	20	23	23	16	99	263
	120					7	4	11	12	14	17	19	20	23	23	16	99	270
	140					7	5	12	15	16	17	19	20	23	23	16	99	277
	160					7	8	14	15	16	17	19	20	23	23	16	99	282
	180					7	10	14	15	16	17	19	20	23	23	16	99	284
	200					7	12	14	15	16	17	19	20	23	23	16	99	286
	220					8	13	14	15	16	17	19	20	23	23	16	99	288
	240					9	13	14	15	16	17	19	20	23	23	16	99	289

320

	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
10			0	0	0	7	0	0	0	3	3	3	7	10	54	92
20			0	0	7	0	0	2	4	5	6	7	10	10	85	141
30			0	0	7	0	2	4	5	7	8	11	15	13	98	175
40			0	7	0	1	4	6	7	8	12	15	19	16	99	199
60			0	7	0	5	6	9	11	13	17	20	23	16	99	231
80			0	7	3	7	9	11	13	17	20	23	23	16	99	253
100	5		0	7	5	9	11	13	17	19	20	23	23	16	99	267
120			0	7	7	12	13	16	17	19	20	23	23	16	99	277
140			7	2	9	12	15	16	17	19	20	23	23	16	99	283
160			7	3	11	14	15	16	17	19	20	23	23	16	99	288
180			7	5	11	14	15	16	17	19	20	23	23	16	99	290
200			7	6	13	14	15	16	17	19	20	23	23	16	99	293
220			7	7	13	14	15	16	17	19	20	23	23	16	99	294
240			7	9	13	14	15	16	17	19	20	23	23	16	99	296

330

	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
10			0	0	0	7	0	0	0	4	3	3	7	10	56	95
20			0	0	7	0	0	3	5	5	6	8	10	10	88	147
30			0	7	0	0	4	4	6	7	9	11	17	13	98	181
40			0	7	0	4	4	6	7	9	12	16	20	16	99	205
60			7	0	2	6	8	9	11	14	17	23	23	16	99	240
80			7	0	6	8	8	13	14	19	20	23	23	16	99	261
100	5		7	2	7	10	13	16	17	19	20	23	23	16	99	277
120			7	4	9	12	13	16	17	19	20	23	23	16	99	283
140			7	6	11	13	15	16	17	19	20	23	23	16	99	290
160			7	8	13	14	15	16	17	19	20	23	23	16	99	295
180			7	10	13	14	15	16	17	19	20	23	23	16	99	297
200			7	12	13	14	15	16	17	19	20	23	23	16	99	299
220			9	12	13	14	15	16	17	19	20	23	23	16	99	301
240			10	12	13	14	15	16	17	19	20	23	23	16	99	302

340

	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	
10		0	0	0	7	0	0	0	2	3	3	4	7	10	59	100
20		0	0	7	0	0	2	3	4	6	5	10	10	10	90	152
30		0	0	7	0	1	4	5	6	8	8	13	17	14	98	186
40		0	7	0	1	4	5	7	7	10	12	17	22	16	99	212
60		0	7	0	5	6	8	9	11	15	20	23	23	16	99	247
80		0	7	2	7	8	10	13	15	19	20	23	23	16	99	267
100	5	0	7	5	9	9	13	16	17	19	20	23	23	16	99	281
120		7	1	7	10	13	15	16	17	19	20	23	23	16	99	291
140		7	2	9	12	14	15	16	17	19	20	23	23	16	99	297
160		7	4	10	13	14	15	16	17	19	20	23	23	16	99	301
180		7	5	12	13	14	15	16	17	19	20	23	23	16	99	304
200		7	6	12	13	14	15	16	17	19	20	23	23	16	99	305
220		7	8	12	13	14	15	16	17	19	20	23	23	16	99	307
240		7	10	12	13	14	15	16	17	19	20	23	23	16	99	309

TABLE 1-23 HELIUM-OXYGEN DECOMPRESSION TABLE and
TABLE 1-23a FOR EXCEPTIONAL EXPOSURES

PARTIAL PRESSURE	BOTTOM TIME (MIN.)	TIME TO FIRST STOP (MIN.)	Decompression Stops (Feet) 180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	TOTAL ASCENT TIME (MIN.)
350	10			0	0	0	7	0	0	0	3	3	3	4	7	10	61	103
	20			0	0	7	0	0	2	4	5	7	8	9	10	10	90	157
	30			0	7	0	0	3	5	5	6	8	9	13	18	14	98	191
	40			0	7	0	2	4	6	7	8	10	13	16	22	16	99	215
	60			7	0	3	5	6	9	10	13	16	18	21	23	16	99	251
	80			7	0	7	7	8	11	13	15	19	20	23	23	16	99	273
	100	5		7	2	8	8	12	13	16	17	19	20	23	23	16	99	288
	120			7	4	9	11	13	15	16	17	19	20	23	23	16	99	297
	140			7	6	11	13	14	15	16	17	19	20	23	23	16	99	304
	160			7	9	11	13	14	15	16	17	19	20	23	23	16	99	307
	180			8	9	12	13	14	15	16	17	19	20	23	23	16	99	309
	200			8	11	12	13	14	15	16	17	19	20	23	23	16	99	311
	220			10	11	12	13	14	15	16	17	19	20	23	23	16	99	313
	240			11	11	12	13	14	15	16	17	19	20	23	23	16	99	314
360	10			0	0	0	7	0	0	0	2	2	3	3	5	7	10	64	108
	20			0	0	7	0	0	0	4	4	5	5	7	9	13	10	94	163
	30			0	0	7	0	1	4	4	5	7	8	11	13	18	14	99	196
	40			0	7	0	1	3	5	6	7	8	11	14	17	23	16	99	222
	60			0	7	0	5	5	8	8	11	12	16	19	23	23	16	99	257
	80			0	7	2	7	7	10	11	13	17	19	20	23	23	16	99	279
	100	5		7	0	6	8	9	11	15	16	17	19	20	23	23	16	99	294
	120			7	1	7	9	12	14	15	16	17	19	20	23	23	16	99	303
	140			7	3	9	11	13	14	15	16	17	19	20	23	23	16	99	310
	160			7	4	10	12	13	14	15	16	17	19	20	23	23	16	99	313
	180			7	5	11	12	13	14	15	16	17	19	20	23	23	16	99	315
	200			7	7	11	12	13	14	15	16	17	19	20	23	23	16	99	317
	220			7	9	11	12	13	14	15	16	17	19	20	23	23	16	99	319
	240			7	11	11	12	13	14	15	16	17	19	20	23	23	16	99	321

EMERGENCY TABLES FOR USE IN HELIUM OXYGEN DIVING

TABLE 1-24 EMERGENCY TABLE (HeO_2)

(FORMERLY TABLE 1-15, 1963 DIVING MANUAL)

Use this Table in an emergency when oxygen cannot be used for decompression, owing to failure of the oxygen supply or to symptoms of oxygen poisoning.

Use a He-O_2 mix containing a minimum of 16% oxygen.

If the impossibility of using oxygen is known in advance, use the regular schedule up to the first oxygen stop, then shift to the Emergency Table (He-O_2).

Decompression Stop Depth (feet)	Decompression Stop Time (min)
50	26
40	30
30	35
20	42
10	55

TABLE 1-25 EMERGENCY TABLE (AIR)

(FORMERLY TABLE 1-16, 1963 DIVING MANUAL)

Use this Table in an emergency when neither oxygen nor He-O_2 can be used during decompression.

Using this Table, rate of ascent to the first stop should be the same as listed in the Partial Pressure Tables, but should not exceed 60 feet/minute. Rate of ascent on subsequent stops is not critical as long as full decompression is received at each stop.

Stops (feet)	Depth up to (feet)— 100	150	200	250	300	350	400
190							3
180							11
170							12
160						9	12
150						13	13
140					4	13	14
130					14	15	15
120					16	16	16
110				13	16	17	17
100				18	18	18	18
90			7	19	19	20	20
80			22	22	22	22	22
70			24	24	24	24	24
60		22	26	26	26	27	27
50		30	30	30	30	30	30
40	14	35	35	35	35	35	35
30	42	42	42	42	42	42	42
20	52	52	52	52	52	52	52
10	68	68	68	68	68	68	68

SATURATION DIVING DECOMPRESSION SCHEDULES

GENERAL INSTRUCTIONS

Divers should normally remain at saturation depth for 24 hr. subsequent to the last excursion for the purpose of re-equilibrium of tissues.

Chamber oxygen environment should be maintained at 0.30 to 0.32 atmosphere; carbon dioxide levels should be maintained less than 0.5% surface equivalent.

Initial Ascent – Represents the initial rapid ascent rate at the commencement of decompression to establish a gradient for inert gas elimination. To find the Initial Ascent Distance, find from the Habitat Internal Credit Table (Table III) the Repetitive Group Designation of the diver who has the most residual helium. The initial ascent distance is given in the table below, opposite the appropriate Repetitive Group Designation letter.

To adequately decompress from a saturated condition the diver must follow **both** the **Daily Routine Schedule** and **Rate of Ascent Schedule** given below:

Daily Routine Schedule

2400-0600	Stop
0600-1400	Ascend
1400-1600	Stop
1600-2400	Ascend

Rate of Ascent Schedule

Initial Ascent	– 10 ft. per hr.
1000 ft.-200 ft.	– 6 ft. per hr.
200 ft.-100 ft.	– 5 ft. per hr.
100 ft.- 50 ft.	– 4 ft. per hr.
50 ft.- 0 ft.	– 3 ft. per hr.

Initial Ascent Distance

Repetitive Group Designation	Feet of Initial Ascent
–	30
A	25
B	20
C	15
D	10
E	5
F	0

SATURATION-EXCURSION DECOMPRESSION SCHEDULES

GENERAL INSTRUCTIONS

In saturation diving the occasion often exists when a diver must make an excursion dive to a depth **greater** (never shallower) than the saturation depth. These tables designate excursion depths and times that a diver may use for excursion dives without requiring decompression. An excursion performed within 24 hours after a previous excursion is a Repetitive Excursion.

DEFINITIONS

Excursion Depth –
the maximum depth, below saturation depth, attained in an excursion expressed in feet of seawater.

Excursion Time –
the elapsed time from leaving the saturation pressure in descent until leaving the excursion depth in ascent expressed in minutes.

Residual Helium Time –
that time which must be added to the bottom time of a repetitive dive to account for helium still absorbed in the body tissue from the previous dive.

RATE OF DESCENT AND ASCENT

The excursion diver shall descend and ascend at a rate no greater than 60 feet per minute. Descent time is included in excursion time and variations in the rate of descent require no adjustment in procedure.

I. **If the ascent rate exceeds 60 feet per minute** – the diver should pause at a pressure 10 feet greater than his saturation depth for the time that should have been taken in an ascent at 60 feet per minute.

II. **If the ascent rate is slower than 60 feet per minute** –

A. If the additional time used in ascent does not take the diver beyond the No Decompression limit for his excursion, then it is only necessary to consider the additional delay as part of the excursion time for subsequent excursions.

B. If the additional time used in ascent takes the diver beyond the no-decompression limit for his excursion, pressurize the habitat to the depth at which the delay occurs. Thereafter, he may safely return to the habitat.

DEPTH LIMITATIONS

Table I should be used when the excursion dives are made from a saturation exposure at any depth in the range from 150 feet to 300 feet of seawater. Table II should be used when the excursion dives are made from a saturation exposure at any depth in the range from 300 feet to 600 feet of seawater. No tables are presently approved for excursion diving from saturation exposures less than 150 feet of seawater.

HABITAT PRESSURE

The saturation pressure of the habitat will normally be kept constant while the excursion diver is absent. The pressure of the habitat may be increased in an emergency and the excursion diver safely brought back to a saturation depth greater than the one from which he left. **Under no circumstances** should the excursion diver be brought back to a habitat saturation pressure **less** than the pressure from which he departed.

HABITAT ATMOSPHERE CONTROL

At any time during the saturation exposure in the habitat deeper than 14 feet seawater, the oxygen partial pressure should be maintained at 0.3 ATA (220 mm Hg.), the carbon dioxide partial pressure should not be greater than 0.0025 ATA (2 mm Hg.), the nitrogen partial pressure should not be greater than 1.2 ATA (900 mm Hg), and the balance of the total pressure should be that of helium.

UBA GAS MIXTURE

The gas mixture supply to the underwater breathing apparatus (UBA) of the diver during the excursion should be helium-oxygen with the proportion and the flow rate adjusted so that the oxygen partial pressure in the diver's inhaled breath (bag level) should generally be between 0.8 ATA and 1.0 ATA (610 to 760 mm Hg.). Fluctuations of the bag level in the range between 0.5 ATA and 1.5 ATA (380 to 1140 mm Hg.) are acceptable. Positive measures should be taken to prevent the oxygen partial pressure falling below 0.4 ATA (305 mm Hg.) or rising above 1.6 ATA (1215 mm Hg.).

TABLES I and II DESCRIPTIONS

No-Decompression Table gives the number of minutes permitted at any excursion depth for a no-decompression excursion.

Repetitive Group Designation Table gives the repetitive group designation for any excursions which may have preceded the repetitive excursion.

Repetitive Excursion Timetable gives the number of minutes of Residual Helium Time which must be **subtracted** from the no-decompression limits of the repetitive excursion to give the maximum actual excursion time which will still permit a no-decompression return to the saturation depth.

Repetitive Group Designation Table gives the repetitive group designation for the sum of the Residual Helium Time and the actual excursion time of the repetitive excursion.

TABLE III DESCRIPTION

Habitat Interval Credit Table gives credit for the release of residual helium from the diver's body during the interval of the saturation pressure of the habitat between excursions.

INSTRUCTIONS FOR THE USE OF TABLES I, II and III

1. **Table I** should be used when the saturation gauge depth is between 150 and 300 feet of seawater.

Table II should be used when the saturation gauge depth is between 300 and 600 feet of seawater.

2. Read the exact, or next greater, depth to which the excursion dive is to be made in the **Depth of Excursion** column.

   Read in the **No-Decompression Limits** column, the maximum allowable excursion time which is permitted without requiring decompression stops.

   Example:
   A 40 foot excursion dive is to be conducted from a saturated depth of 220 feet. What is the allowable excursion time for which no decompression is required?

   USE: Table I – 150 to 300 feet.

   ENTER: **Depth of Excursion** column at "plus 50 feet" (next greater than 40 feet).

   READ: 270 minutes in the **No Decompression Limits** column.

   The diver may spend up to 270 minutes at the 40 foot excursion depth before requiring decompression.

3. Read in the **Repetitive Group Designation** column, the repetitive letter group which corresponds to the actual, or next greater than actual, excursion time.

   Example:
   In the above dive, the diver actually spends 70 minutes at the 40 foot excursion depth. What is his Repetitive Group Designation?

   ENTER: **Depth of Excursion** column at "plus 50 feet."

   READ: horizontally to the 100 minute column (next greater than 70 minutes)

   READ: vertically to the **Repetitive Group Designation** = C

4. **Table III** should be used only when the gauge depth of the saturation exposure is between 150 feet and 600 feet of seawater. Habitat interval time in the Table is in **hours** and **minutes:** 5:30 means 5 hours and 30 minutes. With the repetitive group designation from the previous excursion (from either **Table I or II**) find that letter on the diagonal slope of the table. Enter the table horizontally to select the listed habitat interval that is equal to or **next greater** than the actual habitat interval time. The repetitive group designation for the **end** of the habitat interval is at the head of the vertical column where the selected habitat interval is listed.

   Example:
   After the above dive, the diver spends 6 hours in the habitat. What is his new **Repetitive Group Designation?**

   ENTER: **Table III** on the diagonal slope at the letter C (Group Designation from previous dive).

   READ: horizontally to the 6:30 column (next greater than 6 hours)

   READ: vertically to the new **Repetitive Group Designation** = B

   The diver has lost sufficient inert gas to place him in Repetitive Group B.

TABLE I—Excursion Timetable for Saturation Between 150 and 300 feet

Depth of Excursion From Saturation Exposure	No Decompression Limits (minutes)	Repetitive Group Designation A	B	C	D	E	F
Plus 25 feet	–	60	150	300	600	–	–
50	270	30	60	100	150	210	270
75	150	20	40	65	90	120	150
100	60	10	20	30	40	50	60

NOTE – No Decompression Limit Table, Repetitive Group Designation Table, and Repetitive Excursion Timetable for Excursions from Saturation Exposure at a gauge depth between 150 feet and 300 feet of seawater.

TABLE II—Excursion Timetable for Saturation Between 300 and 600 feet

Depth of Excursion From Saturation Exposure	No Decompression Limits (minutes)	Repetitive Group Designation A	B	C	D	E	F
Plus 25 feet	–	60	150	300	600	–	–
50	270	30	60	100	150	210	270
75	150	20	40	65	90	120	150
100	100	15	30	45	60	80	100
125	75	10	20	30	45	60	75
150	60	10	20	30	40	50	60

NOTE –No Decompression Limit Table, Repetitive Group Designation Table, and Repetitive Excursion Timetable for Excursions from Saturation Exposure at a gauge depth between 300 feet and 600 feet of seawater.

TABLE III—Chamber Interval Credit Table for Saturation Exposure at a Depth Between 150 and 600 Feet of Seawater Depth Gauge

Repetitive Group at the Beginning of the Interval Chamber	Repetitive Group at the End of the Chamber Interval (Before Repetitive Excursion) F	E	D	C	B	A
F	To 1:00	2:30	4:00	6:30	12:00	24:00
E		1:30	3:00	5:30	10:00	24:00
D			2:00	4:00	8:00	24:00
C				2:30	6:30	24:00
B					4:00	24:00
A						24:00

5. If a repetitive excursion dive is to be conducted, enter the **Repetitive Group Designation** column (Table I or II) corresponding to the letter group from the **Habitat Interval Credit table.** Enter the **Depth of Excursion** column corresponding to the exact or next greater depth of the repetitive dive. Read the **Residual Helium Time** at the intersection of these columns.

Example:
Following the above dive, a repetitive excursion dive to 60 feet below the saturation depth is planned for the same diver. How much **Residual Helium Time** does the diver have? How long may the excursion dive be before decompression is required?

ENTER: Table I **Repetitive Group Designation** column under the letter B (group designation from **Habitat Interval Credit Table** after 6 hours in habitat)

ENTER: **Depth of Excursion** column at the "plus 75 feet" depth (next greater than 60 feet)

READ: At intersection of these two columns **Residual Helium Time** = 40 minutes

READ: **No Decompression Limits** column corresponding to the "plus 75 feet" depth = 150 minutes

SUBTRACT: 150-40 **(Residual Helium Time)** = 110 minutes

The diver may remain at the 60 foot excursion depth for 110 minutes before decompression is required.

EMERGENCY ABORT SCHEDULES

GENERAL INSTRUCTIONS:

In the event that a scheduled saturation dive must be aborted prior to reaching saturation conditions, a decompression profile must be run. The decompression rates shown have been calculated for use in the event of an **emergency** occurring under circumstances beyond the scope of the **exceptional exposure tables** (Table 1-23a). The decompression rates used were derived by computer using the Workman Calculation Method. Fifty foot intervals were used as convenient levels for emergency stops. Each depth interval is further subdivided into three exposure conditions, namely 120, 240 and 360 minutes. Use the **next greater** depth and time exposure if the dive is terminated at a level not stated in the Table. For example, if a 40 foot saturation dive is aborted after 150 minutes, the abort schedule to be used would be the 50/240 schedule.

50 FOOT DIVE

50/120

Depth	Rate
50-8	10 ft/min
8-3	2 min/ft
3-0	4 min/ft

50/240

Depth	Rate
50-10	10 ft/min
10-9	6 min/ft
9-5	4 min/ft
5-0	7 min/ft

50/360

Depth	Rate
50-15	10 ft/min
15-12	2 min/ft
12-4	7 min/ft
4-0	9 min/ft

100 FOOT DIVE

100/120

Depth	Rate
100-48	10 ft/min
48-35	1.5 min/ft
35-22	4 min/ft
22-12	6 min/ft
12-0	9 min/ft

100/240

Depth	Rate
100-52	10 ft/min
52-48	1 min/ft
48-39	4 min/ft
39-20	6 min/ft
10-0	20 min/ft

100/360

Depth	Rate
100-54	10 ft/min
54-47	3 min/ft
47-25	10 min/ft
25-0	20 min/ft

150 FOOT DIVE

150/120

Depth	Rate
150-90	10 ft/min
90-74	1 min/ft
74-53	3 min/ft
53-49	5 min/ft
49-25	10 min/ft
25-0	20 min/ft

150/240

Depth	Rate
150-95	10 ft/min
95-90	1 min/ft
90-74	3 min/ft
74-44	10 min/ft
44-0	20 min/ft

150-360

Depth	Rate
150-95	10 ft/min
96-90	3 min/ft
90-60	10 min/ft
60-0	*

*Assume standard saturation dive decompression schedule.

200 FOOT DIVE

200/120

Depth	Rate
200-130	10 ft/min
130-100	1 min/ft
100-90	3 min/ft
90-56	10 min/ft
56-0	*

200/240

Depth	Rate
200-135	10 ft/min
135-130	1 min/ft
130-115	3 min/ft
115-80	10 min/ft
80-0	*

200/360

Depth	Rate
200-136	10 ft/min
136-134	8 min/ft
134-98	10 min/ft
98-0	*

250 FOOT DIVE

250/120

Depth	Rate
250-170	10 ft/min
170-155	1 min/ft
155-135	2 min/ft
135-130	3 min/ft
130-90	10 min/ft
90-0	*

250/240

Depth	Rate
250-175	10 ft/min
175-170	1 min/ft
170-160	2 min/ft
160-120	10 min/ft
120-0	*

250/360

Depth	Rate
250-182	10 ft/min
182-140	10 min/ft
140-0	*

300 FOOT DIVE

300/120

Depth	Rate
300-210	10 ft/min
210-190	1 min/ft
190-170	2 min/ft
170-130	10 min/ft
130-0	*

300/240

Depth	Rate
300-215	10 ft/min
215-200	2 min/ft
200-160	10 min/ft
160-0	*

300/360

Depth	Rate
300-230	10 ft/min
230-185	10 min/ft
185-0	*

350 FOOT DIVE

350/120

Depth	Rate
350-250	10 ft/min
250-220	1 min/ft
220-170	11 min/ft
170-0	*

350/240

Depth	Rate
350-250	2 ft/min
250-200	12 min/ft
200-0	*

350/360

Depth	Rate
350-270	1 ft/min
270-230	12 min/ft
230-0	*

400 FOOT DIVE

400/120

Depth	Rate
400-280	5 ft/min
280-260	2 min/ft
260-210	12 min/ft
210-0	*

400/240

Depth	Rate
400-300	10 ft/min
300-250	12 min/ft
250-0	*

400/360

Depth	Rate
400-330	10 ft/min
330-280	10 min/ft
280-0	*

*Assume standard saturation dive decompression schedule.

Emergency Abort Schedules (Cont.)

450 FOOT DIVE

450/120

Depth	Rate
450-310	5 ft/min
310-280	12 min/ft
280-0	*

450/240

Depth	Rate
450-340	1 ft/min
340-300	12 min/ft
300-0	*

450/360

Depth	Rate
450-370	3 ft/min
370-320	12 min/ft
320-0	*

500 FOOT DIVE

500/120

Depth	Rate
500-360	10 ft/min
360-300	12 min/ft
300-0	*

500/240

Depth	Rate
500-390	2 ft/min
390-340	12 min/ft
340-0	*

500/360

Depth	Rate
500-420	30 ft/min
420-370	12 min/ft
370-0	*

550 FOOT DIVE

550/120

Depth	Rate
550-410	10 ft/min
410-350	12 min/ft
350-0	*

550/240

Depth	Rate
550-440	10 ft/min
440-390	12 min/ft
390-0	*

550/360

Depth	Rate
550-470	30 ft/min
470-420	12 min/ft
420-0	*

600 FOOT DIVE

600/120

Depth	Rate
600-460	30 ft/min
460-400	12 min/ft
400-0	*

600/240

Depth	Rate
600-500	30 ft/min
500-440	12 min/ft
440-0	*

600/360

Depth	Rate
600-520	30 ft/min
520-470	12 min/ft
470-0	*

650 FOOT DIVE

650/120

Depth	Rate
650-510	30 ft/min
510-440	12 min/ft
440-0	*

650/240

Depth	Rate
650-550	30 ft/min
550-490	12 min/ft
490-0	*

650/360

Depth	Rate
650-570	30 ft/min
570-520	12 min/ft
520-0	*

*Assume standard saturation dive decompression schedule

700 FOOT DIVE

700/120

Depth	Rate
700-550	30 ft/min
550-500	12 min/ft
500-0	*

700/240

Depth	Rate
700-590	30 ft/min
590-540	12 min/ft
540-0	*

700/360

Depth	Rate
700-620	30 ft/min
620-570	12 min/ft
570-0	*

750 FOOT DIVE

750/120

Depth	Rate
750-600	30 ft/min
600-540	12 min/ft
540-0	*

750/240

Depth	Rate
750-640	30 ft/min
640-590	12 min/ft
590-0	*

750/360

Depth	Rate
750-670	30 ft/min
670-610	12 min/ft
610-0	*

800 FOOT DIVE

800/120

Depth	Rate
800-660	30 ft/min
660-590	12 min/ft
590-0	*

800/240

Depth	Rate
800-690	30 ft/min
690-640	12 min/ft
640-0	*

800/360

Depth	Rate
800-720	30 ft/min
720-670	12 min/ft
670-0	*

850 FOOT DIVE

850/120

Depth	Rate
850-700	30 ft/min
700-640	12 min/ft
640-0	*

850/240

Depth	Rate
850-740	30 ft/min
740-690	12 min/ft
690-0	*

850/360

Depth	Rate
850-770	30 ft/min
770-720	12 min/ft
720-0	*

*Assume standard saturation dive decompression schedule.

SATURATION DIVING RECOMPRESSION TREATMENT FOR DECOMPRESSION SICKNESS

GENERAL INSTRUCTIONS

Procedures for treating decompression sickness are contained in the U. S. Navy Diving Manual and BUMED INST 6420.2 and have been approved for fleet use; however, with deep saturation dives the risk of decompression sickness occurring under circumstances beyond the scope of the standard procedures is always present. Treatment procedures for use during ascent from saturation dives were developed by the Experimental Diving Unit and have been demonstrated to be effective in the treatment of decompression sickness occurring at deep depths during ascent from saturation dives. The standard procedure contained herein, the **Helium-Oxygen Treatment Method,** is the preferred procedure and should be used for all treatments from depths greater than 60 feet when HeO_2 is available. The **Oxygen Treatment Method** contained herein may be used for treatment of decompression sickness occurring at depths of less than 60 feet.

I. HELIUM-OXYGEN TREATMENT METHOD

A HeO_2 atmosphere should be used for recompression treatment of decompression sickness occurring during saturation dives. Air may be used for recompression treatment only in extreme emergency where HeO_2 is unavailable.

A. Descent Phase

Compress the chamber complex with helium to depth of relief (up to 300 ft.), allowing time for atmosphere mixing to occur. Maintain 5 ft/min. rate of descent if PO_2 can be maintained.

1. **Chamber Atmosphere.** Maintain chamber atmosphere at 0.3 ATA PO_2 (228 mm Hg) if mask HeO_2 is available. If mask breathing is not utilized during descent, increase the chamber atmosphere to 0.4 ATA PO_2 (308 mm Hg).
2. **Mask HeO_2 Mixture.** A 40% O_2 mixture may be used at depths up to 130 feet of seawater (2.0ATA pO_2). A 20% O_2 mixture may be used at depths between 14 and 297 feet of seawater (0.30 to 2.0 ATA pO_2).

B. Equilibration Phase

Stay at depth of relief for a minimum of 2 hours with **all** chamber subjects breathing increased pO_2 according to the following schedule:

20 minutes – HeO_2 by mask (1.5–2.0 ATA pO_2, or 30 min. if pO_2 is less than 1.5 ATA)

30 minutes – chamber atmosphere

20 minutes – HeO_2 by mask (1.5–2.0 ATA pO_2, or 30 min. if pO_2 is less than 1.5 ATA)

30 minutes – chamber atmosphere

C. Ascent Phase

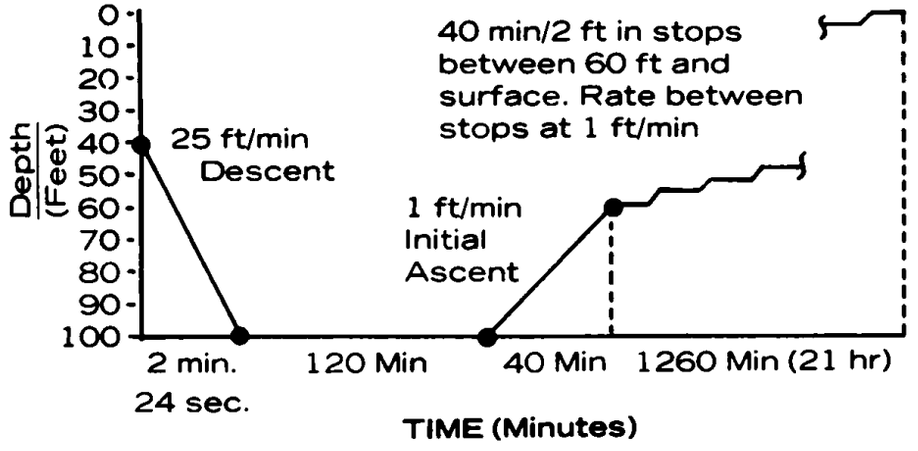
The ascent rate to the first stop should be maintained at 1-foot per minute. After the first stop, the ascent rate should be maintained at 40 min./2 feet in stops. To determine the depth of the first stop during ascent, the following procedure should be used:

1. Calculate the total recompression depth interval.
2. Determine the recompression depth interval in excess of 30 feet.
3. Add 4 feet depth to the original starting depth for each 10 feet depth interval of 2 above.
4. Subtract this value, 3, from the maximum recompression depth obtained.
5. Add 1 foot depth for each 10 feet interval of 4 to the result obtained in 3.
6. This result is the depth of the first stop during ascent.

Example
A diver is recompressed from 40 to 100 feet before relief is obtained. The depth of the first stop during ascent is then:

a. 100 – 40 = 60 feet
b. 60 – 30 = 30 feet
c. $\frac{30 \text{ feet}}{10 \text{ feet}} \times 4 \text{ feet} = 12 \text{ feet}$; 40 + 12 = 52 feet
d. 100 – 52 = 48 feet
e. $\frac{48 \text{ feet}}{10 \text{ feet}} \times 1 \text{ foot} = 5 \text{ feet}$; 52 + 5 = 57 feet
f. Use 60 feet as the first stop

As an example, the total treatment profile would then appear as:



II. OXYGEN TREATMENT METHOD

Oxygen breathing may be used for treatment of decompression sickness occurring at depths of **less than 60 feet.**

A. Descent Phase

Compress the chamber complex to depth of relief (less than 60 feet) allowing time for atmospheric mixing to occur. Maintain 5 ft./min. rate of descent. If relief does not occur in 20 minutes at 60 feet with oxygen breathing, switch patient to HeO_2 if available and use the **Helium-Oxygen Treatment Method** given above.

B. Equilibration Phase

Stay at depth of relief for a minimum of 1 hour breathing **all** chamber subjects according to the following schedule:

20 minutes – oxygen
10 minutes – chamber atmosphere
20 minutes – oxygen
10 minutes – chamber atmosphere

C. Ascent Phase

Ascent is made on oxygen at 1 foot per minute from the depth of relief to a depth 5 feet deeper than the original depth at which treatment began. Ascent to the surface from this depth (original depth + 5 feet) is made at the rate of 40 minutes per 2 feet of depth decrease breathing chamber atmosphere. If the original starting depth is less than 30 feet, a 30 foot stop is inserted and oxygen breathing is interrupted with chamber atmosphere as follows:

30 Foot Stop
10 minutes – chamber atmosphere
20 minutes – oxygen

Ascent to the starting depth plus 5 feet is then made on oxygen, with return to chamber atmosphere breathing at this depth.

Example
A diver starting from an original 10 foot depth obtains relief at 60 feet. The recompression and decompression profile is as follows:

Depth Range	Breathing Mixture	Ascent/Descent Rate
Starting depth 10 feet	Begin oxygen breathing	
Descent 10 to 60 feet	Oxygen	25 ft./min.
Treatment depth 60 feet	20 minutes oxygen 10 minutes chamber 20 minutes oxygen 10 minutes chamber	
Ascend 60 to 30 feet	30 minutes oxygen	1 ft./min.
Mandatory 30 foot stop	10 minutes chamber 20 minutes oxygen	
Ascent 30 to 15 feet	15 minutes oxygen	1 ft./min.
Treatment 15 to 0 feet	300 minutes chamber	40 min/2 feet in stop

NOTES

SECTION 8—GENERAL INFORMATION

FORMULAS FOR ALL UNITS

SYMBOLS & NOTES USED IN THE FOLLOWING FORMULAS

A = Area
C = Circumference
D = Depth of water
H = Height
L = Length
N = Number of divers
R = Radius
T = Tons
V = Volume
Dia. = Diameter
Dia.² = Diameter squared
Dia.³ = Diameter cubed
π **(pi)** = 3.1416
¼ π = .7854
⅙ π = .5236
P.P. = Partial Pressure
psi = Pressure per square inch
psig = Gauge pressure
psia = Absolute pressure
F.P.M. = Feet Per Minute
B.S. = Breaking Strain of line or rope
S.W. = Safe working load of line or rope

NOTES:
Always compute in feet or pounds
One atmosphere = 14.7 psi or 33 feet of sea water.
One foot of sea water exerts .445 psig.
One cubic foot of fresh water displaces 62.4 pounds.
One cubic foot of salt water displaces 64 pounds.
4.5 cubic feet of air per minute absolute required for diver breathing and ventilation requirements.

FORMULA FOR AREAS

The area of a square or rectangle: $A = L \times W$
The area of a circle: $A = .7854 \times Dia.^2$ or $A = \pi R^2$

FORMULAS FOR VOLUMES

The volume of a cube (compartment): $V = L \times W \times H$
The volume of a sphere (balloon): $V = (⅙\pi) .5236 \times Dia.^3$
The volume of a cylinder (pontoon):
$V = .7854 \times Dia.^2 \times L$

LIFTING CAPACITY (IN POUNDS)

Fresh water (V × 62.4) = Weight of lifting unit
Salt water (V × 64) = Weight of lifting unit

FORMULAS FOR AIR REQUIREMENTS

Compressor output (minimum) $(\frac{D}{33} + 1) \times 4.5 \times N$

Over-bottom pressure requirement (D × .445) + 50 psig
NOTE: It is desirable to use 100 psig in depths greater than 120 feet.

FORMULAS REQUIRED FOR HeO_2

Partial Pressure Table P.P.T. =
$(D + 33) \times [1.00 - (O_2 - 0.02)]$

Cut off depth for $O_2 = \frac{66}{O_2\%} - 33$

Maximum $O_2 = \frac{66}{D + 33}$

Effective atmospheres $= \frac{(D + 33) \times O_2\%}{33}$

MISCELLANEOUS FORMULAS

Partial Pressure of a gas –
P.P. = [(D + 33) × .445] × % of gas

Time between stops in seconds –
$T = \frac{(D \text{ left} - D \text{ arrived}) \times 60}{F.P.M.}$

Volume of Decrease (squeeze)
Volume of air remaining
Volume of Increase (Air embolism)
$V = \frac{D \text{ left} + 33}{D \text{ arrived} + 33}$

Emergency Hose Test [(D × .445) + 50] × 2
(Hold pressure for 10 minutes)

FORMULAS FOR SEAMANSHIP

Breaking strain of natural fiber line = $C^2 \times 900$ lbs.

Breaking strain of nylon line = $C^2 \times 2{,}400$ lbs.

Breaking strain of wire = $C^2 \times 8{,}000$ lbs.

Safe working load for 1-2-3 above
¼ B.S. = S.W. for new line or wire
⅙ B.S. = S.W. for average line or wire
⅛ B.S. = S.W. for unfavorable conditions

Safe working load of a shackle = 3 × Dia.² = S.W. in tons

Safe working load of a hook = ⅔ × Dia.² = S.W. in tons

NOTES

SEA STATE CHART

WIND AND SEA SCALE FOR FULLY ARISEN SEA

SEA-GENERAL			WIND		SEA							
					WAVE HEIGHT FEET		MINIMUM DURATION (HOURS)					
							MINIMUM FETCH (NAUTICAL MILES)					
							T (AVERAGE PERIOD)		I (AVERAGE WAVE LENGTH)			
SEA STATE	DESCRIPTION	(BEAUFORT) WIND FORCE	DESCRIPTION	WIND VELOCITY (KNOTS) RANGE (KNOTS)		AVERAGE	AVERAGE 1/10 HIGHEST	SIGNIFICANT RANGE OF PERIODS (SECONDS)				
0	Sea like a mirror	0	Calm	Less than 1	0	0	0	–	–	–	–	–
	Ripples with the appearance of scales are formed, but without foam crests.	1	Light Airs	1-3	2	0.05	0.10	up to 1.2 sec.	0.5	10 in.	5	18 min
1	Small wavelets, still short but more pronounced; crests have a glassy appearance, but do not break.	2	Light Breeze	4-6	5	0.18	0.37	0.4-2.8	1.4	6.7 ft.	8	39 min
	Large wavelets, crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.	3	Gentle Breeze	7-10	8.5	0.6	1.2	0.8-5.0	2.4	20	9.8	1.7 hrs
2					10	0.88	1.8	1.0-6.0	2.9	27	10	2.4
	Small waves, becoming larger; fairly frequent white horses.	4	Moderate Breeze	11-16	12	1.4	2.8	1.0-7.0	3.4	40	18	3.8
3					13.5	1.8	3.7	1.4-7.6	3.9	52	24	4.8
					14	2.0	4.2	1.5-7.8	4.0	59	28	5.2
					16	2.9	5.8	2.0-8.8	4.6	71	40	6.6
4	Moderate waves, taking a more pronounced long form; many white horses are formed. (Chance of some spray).	5	Fresh Breeze	17-21	18	3.8	7.8	2.5-10.0	5.1	90	55	8.3
					19	4.3	8.7	2.8-10.6	5.4	99	65	9.2
					20	5.0	10	3.0-11.1	5.7	111	75	10

5	Large waves begin to form; the white foam crests are more extensive everywhere. (Probably some spray).	6	Strong Breeze	22-27	22	6.4	13	3.4-12.2	6.3	134	100	12
					24	7.9	16	3.7-13.5	6.8	160	130	14
					24.5	8.2	17	3.8-13.6	7.0	164	140	15
					26	9.6	20	4.0-14.5	7.4	188	180	17
6	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind. (Spindrift begins to be seen).	7	Moderate Gale	28-33	28	11	23	4.5-15.5	7.9	212	230	20
					30	14	28	4.7-16.7	8.6	250	280	23
					30.5	14	29	4.8-17.0	8.7	258	290	24
					32	16	33	5.0-17.5	9.1	285	340	27
7	Moderately high waves of greater length; edges of crests break into spindrift. The foam is blown in well marked streaks along the direction of the wind. Spray affects visibility.	8	Fresh Gale	34-40	34	19	38	5.5-18.5	9.7	322	420	30
					36	21	44	5.8-19.7	10.3	363	500	34
					37	23	46.7	6-20.5	10.5	376	530	37
					38	25	50	6.2-20.8	10.7	392	600	38
					40	28	58	6.5-21.7	11.4	444	710	42
8	High waves. Dense streaks of foam along the direction of the wind. Sea begins to roll. Visibility affected.	9	Strong Gale	41-47	42	31	64	7-23	12.0	492	830	47
					44	36	73	7-24.2	12.5	534	960	52
					46	40	81	7-25	13.1	590	1110	57
	Very high waves with long overhanging crests. The resulting foam is in great patches and is blown in dense white streaks along the direction of the wind. On the whole the surface of the sea takes a white appearance. The rolling of the sea becomes heavy and shocklike. Visibility is affected.	10	Whole Gale	48-55	48	44	90	7.5-26	13.8	650	1250	63
					50	49	99	7.5-27	14.3	700	1420	69
					51.5	52	106	8-28.2	14.7	736	1560	73
					52	54	110	8-28.5	14.8	750	1610	75
					54	59	121	8-29.5	15.4	810	1800	81
9	Exceptionally high waves (Small and medium-sized ships might for a long time be lost to view behind the waves.) The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected.	11	Storm	56-63	56	64	130	8.5-31	16.3	910	2100	88
					59.5	73	148	10-32	17.0	985	2500	101
	Air filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.	12	Hurricane	64-71	>64	>80	>164	10-(35)	(18)			

RIGGING DATA

PROPERTIES OF LINE AND CHAIN

Wire Rope Breaking Strength
2000 lb. tons – for bright improved plow steel (BIPS)

Diameter (inches)	6 x 7 FC	6 x 19 IWRC	6 x 19 FC	6 x 37 IWRC	6 x 37 FC	Non-rot 18 x 7	Mooring 6 x 24	Spring lay 6 x 3 x 19
3/8	5.86	6.56	6.10	6.20	5.77	5.59	5.25	–
1/2	10.3	11.5	10.7	11.0	10.2	9.85	9.24	–
5/8	15.9	18.0	16.7	17.0	15.8	15.3	14.3	–
3/4	22.7	25.6	23.8	24.3	22.6	21.8	20.5	–
7/8	30.7	34.6	32.2	32.9	30.6	29.5	27.8	14.9
1	39.7	45.0	41.8	42.8	39.8	38.3	36.1	19.3
1 1/8	49.8	56.6	52.6	53.9	50.1	48.2	45.3	24.3
1 1/4	61.0	65.0	64.6	66.1	61.5	59.2	55.8	29.9
1 3/8	73.1	83.5	77.7	79.7	74.1	71.8	67.1	36.1
1 1/2	86.2	98.9	92.0	94.5	87.9	84.4	79.5	42.8
1 5/8	–	115.0	107.0	110.0	103.0	98.4	92.9	50.2
1 3/4	–	134.0	124.0	128.0	119.0	114.0	106.3	58.0
2	–	172.0	160.0	166.0	154.0	–	138.6	75.3
Minimum sheave dia. / Rope dia.	42	26-33		16-26		–	–	–

NOTES:

1. IWRC = Independent Wire Rope Core
   FC = Fiber Core
2. Deduct 10% from rated strength for galvanized wire rope.
3. Strengths of other wire rope material are:

Material	% of BIPS Strength
Plow Steel	87
Extra IPS	115
304 Stainless	95
Monel	62

4. Safety factors, ratio of breaking strength to working load are normally:
   Standing rigging – 3.5
   Running rigging – 5
   Fittings – 4.5

FIBRE LINE BREAKING STRENGTH

2000 lbs. Tons. S.G. = Specific Gravity

Diameter (inches)	Manila S.G. = 1.38	Nylon S.G. = 1.14	Dacron S.G. = 1.38	Polypropylene S.G. = 0.90
3/8	0.225	0.5	0.5	0.35
1/4	0.3	0.75	0.75	0.55
5/16	0.5	1.25	1.25	0.85
3/8	0.625	1.5	1.5	1.075
7/16	0.875	2.25	2.225	1.25
1/2	1.325	2.75	2.5	1.85
9/16	1.725	3.5	3.3	2.4
5/8	2.2	4.2	4.0	3.0
3/4	2.7	5.75	5.5	3.5
7/8	3.85	8.0	7.75	5.5
Circumference (inches)				
3	4.5	11.0	9.25	6.5
3 1/4	5.25	13.0	10.75	7.4
3 1/2	6.0	14.25	12.5	8.25
3 3/4	6.75	16.5	14.0	9.75
4	7.5	18.75	15.5	10.75
4 1/2	9.25	23.0	19.5	13.0
5	11.25	28.5	24.0	16.0
5 1/2	13.25	34.0	28.5	19.0
6	15.5	40.5	34.0	22.0
6 1/2	18.0	45.0	38.5	25.0
7	20.5	55.0	44.0	30.0
7 1/2	23.25	62.0	50.0	34.0
8	26.0	68.5	55.0	37.5
9	32.0	85.0	70.0	47.0
10	38.5	100.0	82.5	57.5
11	45.5	120.0	100.0	69.0
12	52.5	140.0	115.0	82.0

NOTES:

1. Braided extra-large nylon line strength:

Inches circumference:	13	14	15	18	21
2000 lb. ton breaking strength:	235	272	310	400	625

2. Sisal line has 80% of manila strength.

3. Jute, cotton, hemp have 50% of manila strength.

4. Mylar and "nolaro" (no-lay-rope) are low stretch dacron lines.

5. Elongation under load

Material	% elongation at 10% of breaking strength
Nolaro	1
Mylar	2
Dacron	6
Polypropylene	7
Manila	8
Nylon	11

6. Factors of safety for:

Material	Running Rigging	Standing Rigging
Manila	7	5
Nylon	12	9
Dacron	12	9
Polypropylene	8	6

SYNTHETIC ROPE FITTINGS

Knots & Splices	% of rope strength
Overhand knot	45
Square knot	45
Bowline	60
Clove hitch	60
Short splice	85
Eye splice	95
Long Splice	87
Turn + 2 half hitches	70

Sheave groove widths should exceed rope diameter by 25%.

Sheave diameter should be at least 8 times the rope diameter.

ANCHOR HOLDING POWER

Type of Anchor	lb. per lb. Anchor weight
Concrete or Steel Clump	½
Mushroom	2
Stockless	3
Kedge	5
Northill	30
Eells	20
Spade (Wishbone)	50
Plow	100
Lightweight-mud	50
Lightweight-sand	250

CHAIN WEIGHT AND BREAKING STRENGTH—2000 lb. Tons

Bar Diameter (inches)	Wrought Iron		Carbon Steel		Extra-Strength Di-lok		Super-Strength Di-lok	
	BS	Wt	BS	Wt	BS	Wt	BS	Wt
¾	16.9	0.25	24.3	0.25	37.5	0.25	40.75	0.31
⅞	23.1	0.34	32.6	0.34	49.0	0.34	59.75	0.43
1	30.2	0.45	42.2	0.45	64.5	0.45	78.65	0.56
1⅛	38.2	0.57	53.0	0.57	80.5	0.57	98.2	0.71
1¼	47.2	0.71	65.0	0.71	99.0	0.71	120.75	0.89
1½	65.7	1.02	92.5	1.02	140.0	1.02	170.8	1.25
1¾	86.4	1.36	124.6	1.36	190.0	1.36	231.8	1.7
2	112.9	1.76	161.0	1.76	244.0	1.76	297.5	2.2
2¼	142.8	2.23	201.6	2.23	305.0	2.23	372.0	2.78
2½	176.4	2.76	246.1	2.76	372.0	2.76	453.8	3.45
3	228.6	4.02	346.5	4.02	522.5	4.02	637.5	5.02
3½	276.5	6.00	460.9	6.00	691.6	6.00	843.6	6.85
4	318.0	7.05	588.0	7.05	998.2	7.05	1217.8	8.8
4½	351.6	8.92	726.4	8.92	1254.0	8.92	1529.9	11.12

For anchor lines—minimum safety factor = 3.0
For mooring lines—minimum safety factor = 4.0 or greater

NOTES:

BS = Breaking Strength
Wt = Weight per 15 fathoms shot

WIRE ROPE FITTINGS

Terminations	% of rope strength
Splice	80
Zinc-poured	100
Mechanical	90-95
Wedge Socket	75-90
Screw Sleeve	75-80
U-Bolt Clips	75-80

Sheave groove width should exceed rope diameter by about 5%.

Rope Dia. (inches)	No. of Clips	Clip Assembly
Number of U-Bolt Clips required		
5/16-3/8	3	Clips should be spaced 6 rope diameters apart. U-Bolt portion of clip must be over the bitter end of the rope.
7/16-3/4	4	
7/8-1 1/4	5	
1 3/8-1 3/4	6	

PROPER RIGGING PROCEDURES

1. Wear approved protective hat, leather gloves, safety shoes.
2. Calculate load weight in advance, make sure that crane and lift gear are adequate.
3. Calculate load including entrained water and buoyancy loss when lifting loads from water.
4. **Do not** lift an unknown load out of water.
5. Remove hands from load before signaling. Guide load with hook or other tool.
6. Use safety hook, closed hook, or shackle for attaching load. Do not carry load on hook point.
7. Protect chain or wire sling with rounded wood, rubber tires or heavy cloth.
8. When lifting, raise a small distance and hold to check balance, brakes, and lift capacity.
9. Be careful when lifting small loads. More accidents occur here due to carelessness.
10. Keep angle between legs of a sling as small as possible to keep sling tension low.
    Angle between sling legs: 30° 60° 90° 120° 150°
    Leg tension as % of load: 52 58 70 100 193
11. Do not get between load and fixed objects such as bulkheads or stanchions.
12. Do not get between rear end of crane and fixed objects.
13. Take extra care when handling near-capacity loads and at near-maximum radius.
14. Lift load only when lift line is vertical.
15. Keep hands off cable in motion, especially near sheaves or drums.
16. Keep away from a cable under tension.
17. Remove slings from load carefully and only after tension is fully relieved.
18. **Do not** walk under a load. **Do not** ride on a load.
19. Maintain a neat, uncluttered working area.
20. Take proper care of all rigging equipment.

GAS PURITY STANDARDS

Oxygen

Oxygen is covered by Federal Specification BB-O-925. Three grades of type I (gaseous) oxygen are: Grade A: Aviator's breathing; Grade B: Industrial and medical; Grade C: Technical. Grades A and B, differing only in moisture content, must both contain not less than 99.5 percent oxygen and pass the tests specified by the **U. S. Pharmacopeia** (XIV Revision). Both are acceptable for diving operations. Technical (Grade C) oxygen is not suitable for breathing. To prevent mixups, diving ships and activities should, if possible, avoid having it aboard for any purpose. Activities using oxygen should return cylinders with the valve closed and with a residual pressure of not less than 25 psi. They must avoid damaging or contaminating the cylinders.

Nitrogen

Federal Specification BB-N-411a (1955) and Military Specification MIL-N-6011 (1950) are concerned with nitrogen. Both specifications include oil-free and non-oil-free types. Only oil-free nitrogen is suitable for use in diving. The Federal specification describes three grades of type I (gaseous), class 1 (oil-free) nitrogen:

Grade A: 99.95 percent pure, maximum moisture content 0.02 mg per liter.
Grade B: 99.5 percent pure, maximum moisture content 0.02 mg per liter.
Grade C: 99.5 percent pure, not more than 5 ml of free water per cylinder.

Moisture content of compressed gases is rarely critical in diving, and 99.5 percent purity is satisfactory, provided that the remainder consists of oxygen with no more than a trace of carbon dioxide and with no other contaminants. Hence, Grade A, B, and C nitrogen may be used for diving operations, providing the trace contaminants present are only oxygen and carbon dioxide.

Helium

Helium is produced by the Federal Government. Four Grades—A, B, C, and D—are listed, but only Grades A and D are currently being produced. Grade A helium is approximately 99.999 percent pure and is free of oil and moisture. Grade D is of similar purity except that it is oil pumped and therefore unsuitable for the preparation of breathing mixtures.

Compressed Air

Comparable specifications and purity standards for high-pressure compressed air for breathing have not yet been established. The following are considered as maximum standards for compressed air to be used with surface-supplied air diving or when charging open-circuit scuba cylinders:

Oxygen concentration: 20 to 22 percent by volume.
Carbon dioxide: not more than 0.05 percent (500 ppm).
Carbon monoxide: not more than 0.002 percent (20 ppm).
Oil vapor: not more than 5 mg/m^3.
Gross moisture, dust, or other foreign matter: must be free of these.

In any compressor system care must be taken to ensure that the exhaust of any gasoline engine or **other source** is **not** drawn into the compressor intake. Filtering systems containing activated alumina or other substances that remove carbon dioxide and carbon monoxide must be installed in the compressor system. Compressed air samples should be taken at periodic intervals and submitted to laboratory test for harmful contaminants.

FEDERAL CYLINDER COLOR CODE

The following standards for cylinder identification are used in addition to MIL-STD-101B, "Color Code for Pipelines and for Compressed Gas Cylinders" and "General Requirements for Material Certification of Hyperbaric Facilities," Naval Facilities Engineering

Command, Washington, D.C. Note that Bureau of Standard standards differ slightly from Naval standards.

Gas	Color Code	*Color Code
Oxygen	Green	Green
Helium	Buff	Brown
Air	Black	Black
Helium and Oxygen	Orange	Brown & Green
Nitrogen	Light Grey	
Exhaust	Silver	

*Bureau of Standards, U. S. Dept. of Commerce

These color markings should be applied to the shoulders of the containers so as to be clearly visible. Where the marking is to consist of two colors the pattern should be such as to permit a sufficient amount of both colors to be seen together. The label affixed to each cylinder carrying the name of the gas and the other information required by regulation shall also have the same color or colors as the shoulder. The above color code should be used only as a guide – the primary identification for the gas cylinder contents is the label.

CYLINDER CONNECTIONS AND MANIFOLDING

STANDARD VALVE CONNECTIONS, FEDERAL and COMMERCIAL DESIGNATIONS

General

The following designations represent the standard existing American Standards for compressed gas. Cylinder valve connection systems as published in Compressed Gas Association (CGA) Pamphlet V-1. This pamphlet presents American Standard B57.1-1965 and Canadian Standard B96-1965, and is approved by U.S. Dept. of Commerce, the U.S. Army and the U.S. Navy as well as the Compressed Gas Manufacturer's Association.

Common Abbreviations:

ASTM – American Society for Testing and Materials
BTC-Board of Transport Commissioners for Canada
CGA-Compressed Gas Association
CGMA-Compressed Gas Manufacturers Association
DOT-Dept. of Transportation
ICC-Interstate Commerce Commission
NGT-National Gas Taper
NGO-National Gas Outlet
NPT-National Pipe Taper
NSPL-National Straight Pipe Locking

Thread Outlets

Threaded outlets are separated into four basic divisions – internal (INT) and external (EXT), as well as right-hand (RH) and left-hand (LH). Within each of the four divisions, further separation is made by varying the pitch and diameter of the threads. The diameters within each division are so spaced that adjoining sizes will not enter or engage.

Inlet Threads

Inlet threads on the valve and in the cylinder neck have also been standardized.

Adapters

In the standardization of compressed gas valve outlet connections, more than one adapter is provided for some gases. To provide interchangeability of equipment for the same gas, adapters may be required.

Gases and Connection Symbols

Gas	Standard Connector Nos.
Air	1310, 1340
Helium	580, 930
Helium-Oxygen Mixture[1]	580, 930
Nitrogen	580
Oxygen	540, 870

Conn. No.	Valve Outlet-001 No.	Thread
540	541	.903"-14NGO-RH-EXT
580	581	.965"-14NGO-RH-INT
870		
930		
1310	1311	Yoke Outlet for Air
1340	1341	.825"-14NGO-RH-EXT

Mating Assembly-002 No.	Thread	Nipple 003	Nut 004	Washer 005
542	908"-14NGO-RH-INT	543	544	
582	960"-14NGO-RH-EXT	583	584	
1312	Yoke Connection	1313		1315
1342	.83"-14NGO-RH-INT	1343	1344	

[1]He over 80%

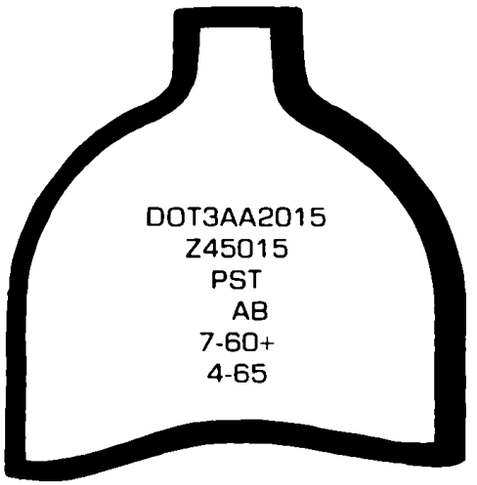
CYLINDER DESIGNATIONS

General

Compressed gas cylinders are constructed and tested in accordance with specifications provided by the Dept. of Transportation (DOT). Older cylinders were constructed and tested by procedures specified by the Interstate Commerce Commission (ICC). Most gas cylinders used in diving gas supply and systems are seamless, high-pressure cylinders designated as DOT-3, DOT-3AX and DOT-3AAX (Previous designations were ICC-3, ICC-3A and ICC-3AA, respectively.) Cylinders designated ICC-3 are older and fabricated of steel with relatively low tensile strength. ICC-3A (DOT-3AX) are seamless steel cylinders especially fabricated for high pressure service. ICC-3AA (DOT-3AAX) cylinders are also seamless, high-pressure service, but are made from heat-treated alloys that withstand higher working stresses than 3A cylinders. Hence, a 3AA cylinder is lighter than a 3A cylinder having the same service.

CYLINDER IDENTIFICATION

Every high-pressure, gas cylinder will have stamped into the shoulder, the following kinds of identification symbols:



DOT (or ICC) material specification, DOT 3AA service working pressure, 2015 psig

Serial no. assigned by mfg., Z45015

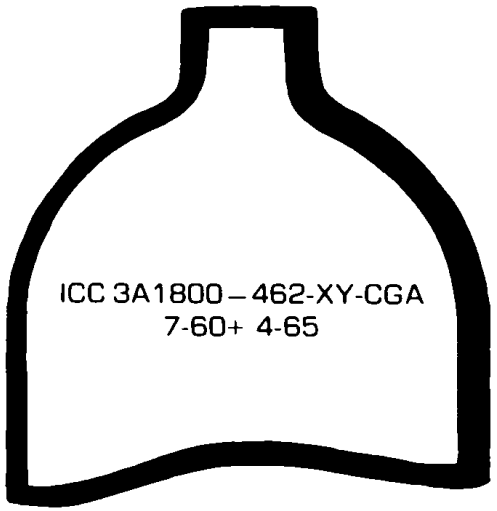
Identification mark of mfg. or owner, PST

Inspector's stamp, AB

Month and year of initial qualification test, 7-60. Allowable 10% over service pressure, and month and year of latest requalification test, 4-65.

To be permitted to carry the 10% overfill allowance (+), the cylinder must be equipped with a DOT-approved

safety device and used for gases approved by ICC 13,302 regulations. In addition, such a designation may only be permitted if the cylinder satisfactorily passes special elastic expansion tests (See Cylinder Testing).



ICC (DOT) material specification, ICC 3A service working pressure, 1800 psig serial no. assigned by mfg. 462 official mark of mfg. inspector XY, cylinder mfg. or owner, CGA.

Month and year of initial qualification test, 7-60 allowable 10% over service pressure and month and year of latest requalification test, 4-65.

CYLINDER TESTING

GENERAL

DOT regulations require that all high-pressure gas service cylinders be retested within every five (5) year period. The testing to be accomplished includes both a visual inspection and a hydrostatic test. The details of these procedures are contained in CGA Pamphlet C-6 and CGA Pamphlet C-5, respectively. The hydrostatic test recommended (water jacket volumetric expansion method) consists of enclosing the cylinder in a vessel completely filled with water, measuring in a suitable device attached to the vessel the total and permanent volumetric expansion of the cylinder, by measuring the amount of water displaced by expansion of the cylinder when under pressure and after pressure is released.

SAFETY DEVICES

All high-pressure gas cylinders are required by DOT regulations to be protected by one or more safety devices. The safety devices include relief valves, frangible discs and/or fusible plugs. The detailed specifications for these devices may be found in CGA Pamphlet S-1.1. A "safety relief valve" is a device containing an operating part that is held normally in a position closing an opening by spring force and is intended to open and to close at predetermined pressures. A "frangible disc" is an operating part in the form of a disc, usually of metal, which is held as to close an escape opening under normal conditions. The disc is intended to burst at a predetermined pressure to permit escape of gas. A "fusible plug" is an operating part in the form of a plug of suitable low melting material usually a metal alloy, which closes an escape opening under normal conditions and is intended to yield or melt at a predetermined temperature to permit escape of gas.

MANIFOLDING ARRANGEMENTS

GENERAL

Piping for U. S. Navy high pressure gas systems shall conform to MIL-T-1368. All metal pipe and tubing used in oxygen supply and distribution systems, at pressures over 100 psig, must be made from material in the annealed condition. The burst strength of all pipe tubing and hose must be at least three times working pressure. The metal used in systems with working pressure of 1000 psi, or above, should be a nickle-copper alloy. In use at pressure below 1000 psi, copper or brass tubing is acceptable. The use of non-metallic armored hose for the distribution of oxygen is acceptable at any pressure up to 5000 psi. For non-interchangeable fittings, CGA specifications are applicable. In addition, flareless fittings (MIL-F-24167) may be used if care is taken to insure leak and crack-

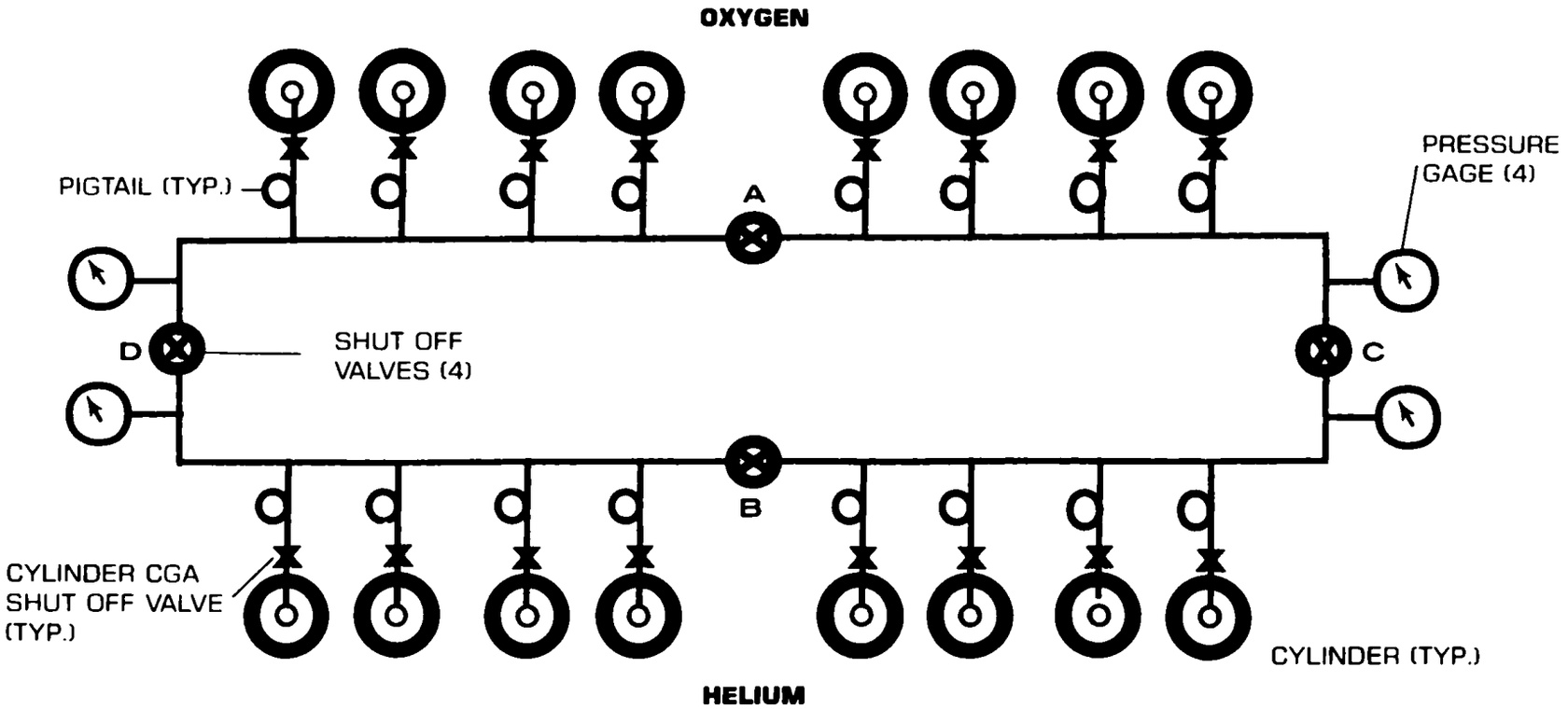
free joints. Brazed and welded fittings for high pressure systems may be used if the requirements for leak testing and cleaning are not overlooked.

HeO_2 MIXING MANIFOLDING

Helium-oxygen mixtures may be obtained by either the single-cylinder or multiple-cylinder mixing process. In the single-cylinder method a simple "splitting-T" manifold is used.

To reduce the pressure of the filled cylinder prior to mixing, a splitting-T compatible to each of the gases is required. That is, a O_2-O_2 and a He-He T are required.

For multiple-tank mixing, a system shown in the below schematic would be used.



PRESSURE GAGE MAINTENANCE

CARE

Serious difficulties in diving can arise from the use of faulty or inaccurate pressure gages. Pressure gages are delicate instruments and, as such, require careful treatment. During shipment, if not part of installed equipment, gages should be separately packaged. During removal or disconnection from the pressure system, protective caps should be installed to prevent inclusion of foreign particles and also to prevent thread damage. Manufacturers instructions regarding temperature, fluid and pressure exposure should be strictly adhered to. All gages must be checked at least once every 12 months in accordance with NAVSHIPS Technical Manual, Chapter 87-14, unless a malfunction requires repair or calibration more frequently. If the gage is part of an oxygen system that is being cleaned (see Section B-1, U.S. Navy Diving Manual), the gage should be removed and cleaned separately. This is to assure that the gage lines are thoroughly flushed and there are no dead ends in the system. Finally, some gages may be damaged by the heated detergent solution.

CALIBRATION

1. Gage readings in depth, feet of sea water, are especially important in diving. Since almost all gage testers are graduated in pounds per square inch, conversions are needed.
2. An appropriate number of points should be checked depending on the scale of the gage and the increments available with the tester.
3. At each increment of pressure, the actual reading of the gage being tested should be recorded, together with the true depth that corresponds to the pressure.
4. In testing a gage, it is desirable to run more than one test (or at least to note readings both with increasing and decreasing steps of pressure) to check the consistency of errors. A gage that shows large or variable errors, or one that sticks excessively, should be turned over for repairs or surveyed.
5. An attempt may be made to adjust a gage according to article 87-17 of the NAVSHIPS Technical Manual. If this is not done or is not wholly successful, a calibration curve (graph) or table must be prepared to indicate the relationship between true depths and gage readings. If the deviations are within 5 feet of true depth and vary less than 2 feet in a 50-foot change of depth, 50-foot increments must be used in the calibration table. If the deviations are greater than this, 10-foot increments must be used. (In such a case, readjustment, repair, or replacement of the gage is actually preferable.)
6. The calibration table should be affixed to the inside of the gage face glass. It should include this information:
   A. Identification of depth gage.
   B. True depths in feet.
   C. Corresponding actual gage readings.
   D. Name of ship or activity.
   E. Initials of individual responsible.
   F. Date of calibration.
7. In using a gage with such a table, some interpolation is necessary. A calibration graph, with true depth on one axis and actual reading on the other, would permit more exact and more rapid corrections.

WRIST DEPTH GAGES

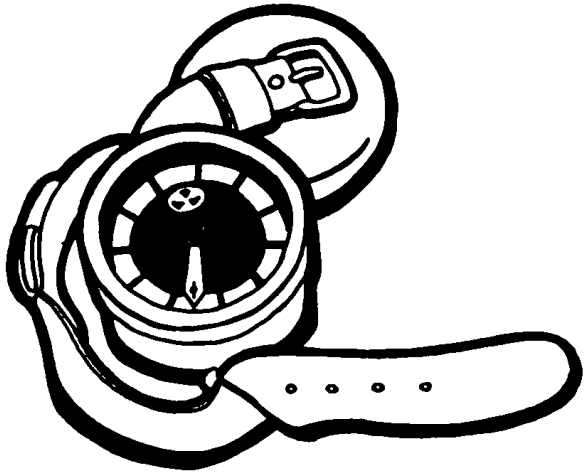
CARE

The diver's wrist depth gage, being basically a precision pressure gage, is a delicate instrument and requires careful treatment. Although most wrist depth gages are constructed of corrosion-resistant materials and are shock resistant, serious and irreparable damage to the instrument can be caused by neglect and abuse. The following comments represent a summary of maintenance practices that will improve the use and longevity of the gage.

1. Keep dial-cover strap on gage and dial cover (if equipped) over dial when gage is not in use.
2. Flush gage with fresh water after each use.
3. Keep water chamber opening free of sediment and corrosion.
4. Periodically check gage calibration.
5. Dispose of radioactive material in accordance with AEC regulations.

CALIBRATION

Periodically check the calibration of the gage by placing it in a compression chamber or by comparing indications in sea water with the depths shown by a sounding line.



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