Operating Standards for NOAA Hyperbaric Chambers

TABLE OF CONTENTS

Section 1: INTRODUCTION

The following standards and procedures were established by the NOAA Diving Program to provide criteria, specifications, and requirements for operating NOAA hyperbaric chambers. These standards and procedures were developed to provide NOAA personnel with information to outfit, man, and operate hyperbaric chambers safely and effectively in support of NOAA diving operations.

All hyperbaric chambers used by NOAA personnel shall meet established operational policies and training requirements outlined in the latest revisions of the NOAA Diving Manual and the US Navy Diving Manual.

Conditions may warrant actions contrary to the dictates of this standard. Deviations from any operational standards, policy, or procedures in this Standard, must be approved beforehand by the Director, NOAA Diving Program or his/her designee.

Section 2: PERSONNEL REQUIREMENTS

2.1 Manning Levels

The following lists are the minimum personnel requirements and positions for conducting chamber operations. A Diving Medical Officer shall be on-call and immediately accessible for consultation at all times when chambers are in operation.

2.1.1 Multi-lock recompression chambers

Supervisor/Operator	1
Inside Tender	1
Time/log keeper/systems operator	1
Total	3

2.1.2 Mono-lock/Multi-place recompression chamber

Supervisor/Operator	1
Inside Tender	1
Time/log keeper/systems operator	1
Total	3

2.1.3 Mono-lock/Mono-place recompression chamber

Supervisor/Operator	1
Time/log keeper/systems operator	1
Total	2

2.2 Personnel Responsibilities and Qualifications

2.2.1 Chamber Supervisor

A. Responsibilities

1) Assigns and supervises chamber personnel

2) Supervises and directs all chamber and chamber-related operations

3) Ensures operations are conducted and documented properly according with established standards

4) Coordinate treatment procedures with medical personnel and Vessel Captain

B. Qualifications

1) Demonstrated proficiency in the supervision and operation of recompression chambers during operations and treatment procedures

2) Demonstrated proficiency in diving accident management

3) Must be approved by the DPM

4) Must be a current NOAA-Diving Medical Technician (DMT) or equivalent.

2.2.2 Chamber Operator

A. Responsibilities

1) Controls and maintains all gases entering and exiting the chamber

2) Pressurizes and de-pressurizes chamber

3) Monitors and regulates inside chamber atmosphere

4) Communicates with personnel inside the chamber

B. Qualifications

1) Demonstrated knowledge of the recompression chamber and related systems

2) Demonstrated proficiency in the operation of the recompression chamber and related systems

3) Must be approved by the Chamber Supervisor

2.2.3 Inside Tender

A. Responsibilities

1) Provides normal and emergency assistance as required inside and outside the recompression chamber

2) Opens and closes inside hatch

3) Communicates with outside personnel

4) Administers medical aid and therapy breathing gas as directed by the Chamber supervisor

5) Monitors the condition of personnel in the chamber

6) Ensures hearing protection is worn during compression and ventilation phases of recompression treatment

B. Qualifications

1) Demonstrated proficiency in diving accident management and emergency medical care

2) Must maintain medical clearance to dive in accordance with the NOAA Diving Medical Standards and Procedures Manual (NDMSPM).

3) Must be a current NOAA-certified DMT or equivalent

4) Must be approved by the Chamber Supervisor

2.2.4 Time/log keeper

A. Responsibilities

1) Records data during chamber operations including, depths, times, significanttreatments, responses, events, communications, and chamber atmosphere

2) Keeps Chamber Supervisor and/or Operator informed of depth, time, and gas requirements

B. Qualifications

1) Familiarity with chamber treatment tables, dive log and timekeeping devices

2) Ability to follow instructions and record information precisely and neatly

3) Must be approved by the Chamber Supervisor

2.2.5 NOAA Diving Medical Officers (DMO)

A. Responsibilities

1) Prescribing and modifying as necessary, hyperbaric chamber treatment procedures in consultation with the Chamber Supervisor and NDP DMO.

2) Prescribing and administering appropriate medications and advanced life saving techniques in a hyperbaric environment in consultation with the NDP DMO.

B. Qualifications

1) Attended and successfully completed NOAA/UHMS Diving Physicians course or equivalent

2) Must complete a pressure test inside a chamber prior to assuming duties as DMO and maintain medical clearance per the NDMSPM.

3) Must be approved by the Chairman, NOAA Diving Medical Review Board

2.2.6 NOAA Diving Program DMO

A. Responsibilities are the same as for a NOAA DMO with the following additions:

1) Direct consultation with the Navy Diving and Salvage Training Center DMOs or the Navy Experimental Dive Unit DMOs.

2) Coordinates treatments of NOAA diving casualties in order to ensure the best and most expeditious care.

3) Maintains medical records for all NOAA divers.

B. Qualifications are the same as for a NOAA DMO with the following additions:

1) Attended and successfully completed NOAA/UHMS Diving Physicians course and the US Navy Recognition and Treatment of Diving Casualties Course.

2) Must be a certified NOAA diver.

3) Must be appointed by the Director of Health Services, OMAO.

Section 3: EQUIPMENT REQUIREMENTS

3.1 Chamber Equipment and Systems

The following equipment and systems are considered the minimal configuration for manned chamber operations. All of the following items and systems must be functional in order to conducted manned chamber operations:

3.1.1 Containerized Double-lock Chamber System

This system consists of a Standard Double Lock recompression chamber and gas supplysystem housed in an environmentally controlled International Organization for Standards (ISO) container. The container protects the chamber, electrical equipment, ancillaryequipment and personnel from weather and harsh environments. The system is capable of supporting surface decompression, medical treatment, and training operations. It isoutfitted with a stretcher, BIBS, gas monitoring systems, lights, fire suppression, and anenvironmental conditioning system. There shall be stopwatches or similar timing systemavailable at the chamber.

3.1.2 Mono-lock/Mono & Multi-Place Chambers

This system consists of a chamber in which there is only one lock. It may be a monoplace chamber such as the SOS Hyperlite (Emergency Evacuation Hyperbaric Stretcher or EEHS) or similar larger vessel capable of pressurizing more than one person. The chamber iscapable of supporting medical treatment and training operations. It is outfitted with astretcher, BIBS, and gas monitoring systems. There shall be stopwatches or similartiming system available at the chamber. In the case of the EEHS, it is a manually portable single patient hyperbaric tube used to transport a diving casualty from an accident site to atreatment facility while under pressure. The EEHS is small enough to allow transfer of apatient, under pressure, into or out of many shore based recompression chambers. Insome locations in which transport under pressure is not safe or feasible, the EEHS could be used for initial hyperbaric treatment with planned evacuation of the patient aftertreatment.

3.1.3 Gas Supply

A recompression chamber should have a primary and secondary air supply system that satisfies table 3.1. The purpose of this requirement is to ensure the recompression chamber system, at a minimum, is capable of conducting a treatment table 6A for multi- lock chambers, and treatment table 6 for mono-lock chambers. Either system may consist of air banks and/or a suitable compressor. The primary air supply system must have sufficient air to pressurize the inner lock once to 165 fsw and the outer lock twice to 165 fsw and ventilate the chamber as specified in table 3.1. For mono-place chambers, the primary air supply system must have sufficient air to pressurize the chamber to 60 fsw once and to ventilate the chamber as specified in table 3.1.

Recompression Chamber Configuration	Primary Air Requirements	Secondary Air Requirements
Standard Double Lock, multi-person chamber	Sufficient air to press the inner lock once and the outer lock twice to 165 fsw and vent for CO2 during one TT6A for one patient and two tenders with maximum extensions.	Sufficient air to press the inner lock and outer lock once to 165 fsw and vent for one hour at 70.4 scfm.
Mono-lock chambers	Sufficient air to press the chamber to 60 fsw once and vent for CO2 during one TT6 with maximum extensions according to the number of occupants	Sufficient air to press the chamber to 60 fsw and vent for one hour at 70.4 scfm.*

Table 3.1
* In the case of a treatment table utilizing the SOS Hyperlite, a secondary air supply delivery option is not available.

3.1.4 Medical Supplies

A. The contents of the emergency kits listed in Appendix 1 are not meant to be restrictive but are considered the minimum requirement. Additional items may be added to suit localmedical preferences. Because some sterile items may become contaminated as a result of a hyperbaric exposure, it is desirable to have a primary kit for immediate use inside the chamber and a secondary kit from which items that may become contaminated can belocked into the chamber only as needed.

1) The primary emergency kit contains diagnostic and therapeutic equipment thatis available immediately when required. This kit shall be inside the chamber during all treatments.

2) The secondary emergency kit contains equipment and medicine that does not need to be available immediately, but can be locked-in when required. This kit shall be storedin the vicinity of the chamber.

Section 4: OPERATIONAL PROCEDURES

4.1 Treatment

4.1.1 Decision to Treat

In the event of a diving incident, the decision to treat shall be made in consultation with the chamber supervisor, the on-site DMO, and the NDP DMO. If the three parties are unableto come to a consensus regarding the need for hyperbaric treatment, additionalconsultation may be obtained from the Navy Diving and Salvage Training Center (NDSTC) DMO, Navy Experimental Diving Unit (NEDU) DMO, or Duke Dive Medicine. For urgentconsultation, the NDP DMO may consult with the DMO on call at NDSTC, NEDU, or Duke Dive Medicine. The NOAA Diving Medical Review Board (NDMRB) may be consulted fornon-urgent inquires or for questions regarding return to diving.

The vessel captain should be kept informed of recommended treatments. This individualcould override the decision to treat if it would cause a severe safety issue for the vessel orother crew. Should the vessels Captain choose to delay treatment, surface oxygen should be used for all cases of DCS until the diver can be recompressed. Use of a high flow 15 lpm oxygen source or a demand valve can achieve high inspired fractions of oxygen. Oneconsideration in administering surface oxygen is pulmonary oxygen toxicity. 100% oxygencan generally be tolerated up to 12 hours. The patient may be given air breaks as necessary. If oxygen is being administered beyond the 12 hours then a decision tocontinue must weigh the perceived benefits against the risk of pulmonary oxygen toxicity.The risk evaluation must also consider the dose of oxygen anticipated with subsequent recompression therapy as well. Lines of communication are outlined in Figure 4.1.

4.1.2 Pre-dive

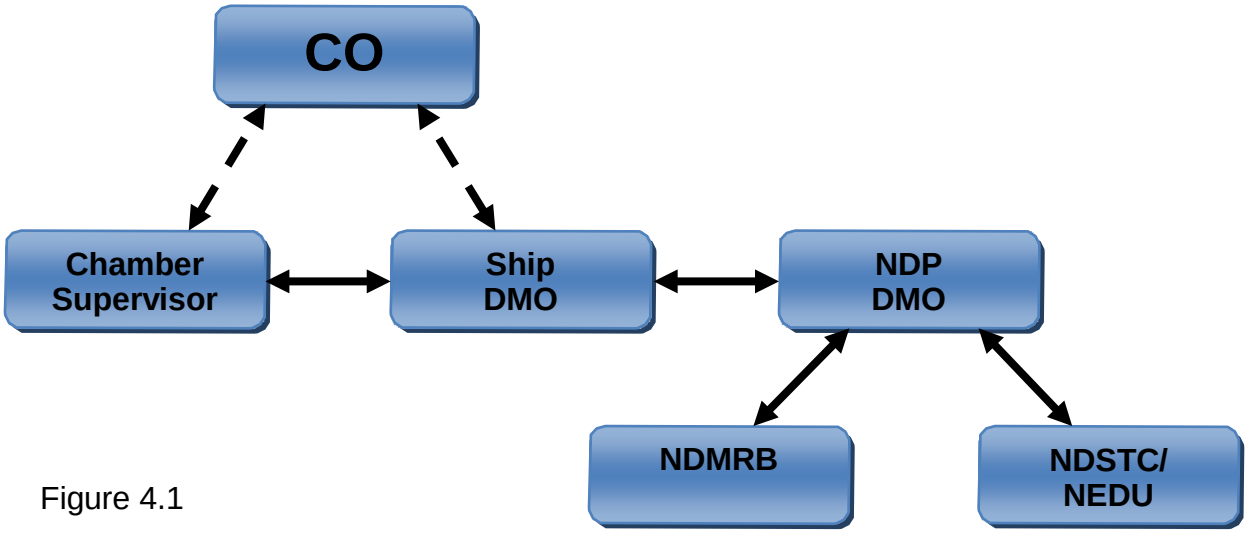


Figure 4.1

Prior to operation of the chamber, a NDP chamber pre-dive checklist shall be completed(Appendix 2). Prior to commencement of recompression treatment, the ChamberSupervisor shall make appropriate effort to consult with a NOAA DMO. The options forcontact include the ship board DMO, the NDP DMO, and the Director of Health Servicesfor OMAO. If unable to contact a NOAA DMO within 10 minutes, the chambersupervisor may contact the NDSTC DMO on call or DAN. If unable to contact a NOAA DMO, theprocedures outlined in Section 4.3 of this document shall be followed.

The NDC DMO shall be contacted as soon as possible, but not so as to delay treatment. If recompression treatment is required, the NDC DMO shall contact the Director, NOAADiving Program, and the Director of Health Services for OMAO at the first appropriateopportunity to inform them of the situation and the planned course of action.

4.1.3 During Chamber Treatment

Should recompression treatment be required, the Chamber Supervisor shall regularly consult with a NOAA DMO at appropriate times throughout the treatment. Unless directly authorized by a NOAA DMO, the Chamber Supervisor shall not deviatefrom the prescribed treatment procedures outlined in the reference material in Section 4.2 below.

4.1.4 Post-dive

Upon completion of chamber operations, the patient should be seen by a NOAA DMO. If a DMO is not available on-site, the Chamber Supervisor shall contact the DMO for further instructions. A NDP chamber post-dive checklist shall be completed at the conclusion of chamber operations (Appendix 2). The recompression chamber shall be maintained in astate of readiness prior to, during and following all dives for a minimum of one (1) hour.

4.1.5 Inside Tender Considerations

Treatment Table (TT)	O2 Breathing Times
TT5 with or without extensions	**0**
TT6 with up to one extension @ 60 fsw or 30 fsw	**30 min**
TT6 with more than one extension	**60 min**
TT6A with up to one extension @ 60 fsw or 30 fsw	**60 min**
TT6A with more than one extension	**90 min**
If the tender had a previous hyperbaric exposure within 18 hours: • for TT5, add 20 min O2 breathing • for TT6 or TT6A, add 60 min O2 breathing to the times in the table.	

Table 4.1

Treatment table profiles place the inside tender(s) at risk for decompression sickness. After completing treatments, inside tenders should remain in the vicinity of the recompression chamber for one hour. If they were tending for treatment table 4, 7, or 8, inside tenders should also remain within 60 minutes travel time of a recompression facility for 24 hours. Tenders on treatment tables 5, 6, 6A, 1A, 2A, or 3 should have a minimum of an 18 hour surface interval before no-decompression diving and a minimum of a 24 hour surface interval before dives requiring decompression stops. Tenders on treatment tables 4, 7, and 8 should have a minimum of a 48 hour surface interval prior to diving.

In order to mitigate the risk of DCS of an inside tender, they should breathe oxygen according to table 4.1. All tender O2 breathing times are conducted at 30 fsw. In addition, tenders will breathe O2 on ascent from 30 fsw to the surface. In some cases, the tender's oxygen breathing obligation may exceed the table stay time at 30 fsw. In this case, extend the time at 30 fsw to meet these obligations if the patient's condition permits. Otherwise, administer O2 to the tender to the limit allowed by the treatment table and observe the tender on the surface for one hour for symptoms of DCS.

4.2 Operating Standards & Authority

4.2.1 Chamber Operations

A. All chamber operations shall be conducted in accordance with procedures outlined in the latest versions of the US Navy and NOAA Diving Manuals.

B. In situations where a NOAA DMO is not available at the chamber, a list of telephone numbers for alternate DMO's shall be established and verified prior to commencing dive operations where a chamber is required on-site.

4.2.2 Authority Level

A. The designated Chamber Supervisor is responsible for the operation of the recompression chamber and the safety of the patient and tenders. They have decision making authority in collaboration with the DMO for aspects related to operation of the chamber.

B. Emergency conditions may warrant actions contrary to the dictates of this document. The Chamber Supervisor is authorized to deviate as necessary to prevent or minimize harm to human life.

C. Any deviation from these standards and procedures must be reported to the DPM within 24 hours of the occurrence.

4.3 NOAA Standing Orders

The following standing orders are to be followed for the treatment of Decompression Sickness and/or Arterial Gas Embolism in the event a qualified DMO is not available at the chamber:

4.3.1 General Medical Instructions

A. Immediate Care for a Conscious Patient

1) Administer 100% oxygen

2) Remove exposure suit, dry, and keep warm

3) Place in position of comfort

4) Take vital signs every 5-mins if unstable and every 15-mins if stable

5) Pulse/per min

6) Blood pressure

7) Respirations/per min

8) Gather dive history info from diver/buddy

9) Perform neurological exam

10) Contact medical assistance or EMS

11) Administer 0.5 liters of water orally per hr x 2 hrs, then reduce to 100-200 ml per hr thereafter

12) If unable to drink sufficient quantities of fluids orally, start IV with Lactated Ringers or Normal Saline

13) Administer 0.5 liters per hr x 2 hrs

14) Then reduce to 100-200 ml per hour thereafter

15) If unable to urinate 30 cc's/hour voluntarily, insert Foley catheter and monitor urine output quantity and appearance

B. Immediate Care for an Unconscious Patient

1) Establish responsiveness, circulation, airway, and breathing

2) Administer 100% oxygen

3) Remove exposure suit, dry, and keep warm

4) Lateral recumbent position

5) Take vital signs every 5-mins

6) Pulse/per min

7) Blood pressure

8) Respirations/per min

9) Gather dive history info from dive buddy and/or eye witnesses

10) Perform neurological exam & Glascow Coma Scale

11) Contact medical assistance or EMS

12) Start IV with Lactated Ringers or Normal Saline

13) Administer 0.5 liters per hr x 2 hrs

14) Then reduce to 100-200 ml per hour thereafter

15) Insert Foley catheter and monitor urine output quantity and appearance

16) If victim does not regain consciousness once at depth, an NG tube should be placed.

4.3.2 Type I DCS

A. Place diver on 100% oxygen and contact a NOAA DMO for instructions prior to pressurizing the diver in a recompression chamber.

B. If a NOAA DMO cannot be contacted immediately, or signs/symptoms indicate progression to Type II DCS, pressurize diver to 60 fsw (2.8 ata) and begin a US Navy Treatment Table 6 (TT6).

C. Continue to try and contact a NOAA DMO for instructions. If a NOAA DMO cannot be contacted, continue USN TT6 until completion according to flow chart 3 in appendix 2.

4.3.3 Type II DCS or AGE

A. Immediately pressurize diver to 60 fsw (2.8 ata) and begin a US Navy TT6.

B. Contact a NOAA DMO as soon as possible for further instructions.

C. If a NOAA DMO cannot be contacted, follow flow chart 1 in appendix 2 and continue treatment in accordance with procedures outlined in the USN Diving Manual. Contact the NDSTC DMO on call or DAN if unable to contact a NOAA DMO

4.4 Post Hyperbaric Treatment Considerations

4.4.1 Post Treatment Observation Period

After a treatment, patients treated on a TT5 should remain at the recompression chamber facility for 2 hours. Patients who have been treated for Type II DCS or who required a TT6 for Type I DCS symptoms and have had complete relief should remain at the recompression chamber facility for 6 hours. Patients treated on TT6, 6A, 4, 7, 8, or 9 are likely to require a period of hospitalization, and the DMO will need to determine a post-treatment observation period and location appropriate to their response to recompression treatment. All patients should remain within 60 minutes travel time of a recompression facility for 24 hours and should be accompanied throughout that period. No patient shall be released until authorized by a DMO.

4.4.2 Flying After Treatments

Patients with residual symptoms should fly only with the concurrence of a DMO. Patients who have been treated for DCS or AGE and have complete relief should not fly for 72 hours after treatment, at a minimum.

Tenders on TT5, 6, 6A, 1A, 2A, or 3 should have a 24 hour surface interval before flying. Tenders on TT4, 7, and 8 should not fly for 72 hours.

4.4.3 Emergency Air Evacuation

Some patients will require air evacuation to another treatment or medical facility immediately after surfacing from a treatment. They will not meet surface interval requirements as described above. Such evacuation is done only on the recommendation of a DMO. Aircraft pressurized to one ATA should be used if possible, or unpressurized aircraft flown as low as safely possible (no more than 1,000 feet is preferable). Have the patient breathe 100% oxygen during transport, if available. If available, an EEHS may be used to maintain the patient at one ATA.

4.5 Guidelines for Non-Standard Scenarios and Situations

The following guidelines are provided to aid the chamber supervisor/operator and DMO in responding to non-standard problems that are not addressed in Section 3.2.2 of thisdocument.

4.5.1 Inability to equalize ears during travel

A. Conscious victim

1) Type I DCS

a. Stop descent, ascend a few feet and try equalizing

b. If still unable to clear after several tries, return chamber to surface and administer a nasal decongestant spray

c. Wait until patient is able to auto-inflate their middle ear, then begin pressurization in chamber

2) Type II DCS or AGE: Depending on the symptoms the chamber supervisor may elect to try one or more of the steps listed above

B. Unconscious victim: Do not delay, begin pressurization to 60 feet in the chamber immediately.

C. Consider needle tympanotomy if time permits prior to taking patient to depth.

4.5.2 Confined Space Anxiety Syndrome (Claustrophobia)

A. Try to calm and reassure patient

B. If necessary, the DMO may direct giving patient Lorazapam (Ativan) orally – dosage to be determined by the DMO

4.6 Omitted Decompression

4.6.1 Symptomatic

If diver displays signs or verbalizes symptoms at any time, the diver should be started on a treatment table 6.

4.6.2 Recognition of Omitted Decompression

Should a diver realize that they have exceed the no-decompression limits **prior to reaching the surface**, and they do not have access to USN decompression tables to determine required in-water decompression time, they should:

A. Stop at 10-15 fsw for a minimum of 15 minutes or until they reach 300 psi in their cylinder, whichever comes first

B. Once on the surface, they should consult the USN Standard Air Decompression Tables to see if they met the required decompression time. If so, they should refrain from diving for a minimum of 6 hours.

C. If they didn't meet the required time, they should be placed on oxygen for a minimum of 60 minutes, observed and restricted from diving for 12 hours.

4.6.3 Failure to Recognize Omitted Decompression

A. Situation 1
Should a diver not realize that they have exceeded the no-decompression limits prior to reaching the surface, **and no stops deeper than 20 fsw were missed,** they should:

1) Notify divemaster of the omitted decompression

2) If asymptomatic, and the diver can be returned safely to the water within 5 minutes after surfacing, they should dive to the depth of the missed decompression stops and remain for 1 ½ times the required decompression stop time.

3) If the diver cannot be returned to the water within 5 minutes, they should be placed on oxygen for a minimum of 60 minutes.

4) If asymptomatic after 60 minutes of oxygen, they should be observed for a minimum of 12 hours for signs and symptoms of DCS and restricted from diving during this observational period.

B. Situation 2
Should a diver not realize that they have exceeded the no-decompression limits prior to reaching the surface, **and one or more stops deeper than 20 fsw were missed,** a treatment table 6 should be initiated.

4.7 ABORT PROCEDURES

Once recompression therapy is started, it should be completed according to the procedures in this chapter unless the diver being treated dies or unless continuing the treatment would place the chamber occupants in mortal danger or in order to treat another more serious medical condition.

4.7.1 Death During Treatment

If it appears that the diver being treated has died, a Diving Medical Officer shall be consulted before the treatment is aborted. Once the decision to abort is made, there are a number of options for decompressing the tenders depending on the depth at which the death occurred and the preceding treatment profile.

If death occurs following initial recompression to 60, 165, or 225 on Treatment Tables 6, 6A, 4 or 8, decompress the tenders on the Air/Oxygen schedule in the Air Decompression Table having a depth exactly equal to or deeper than the maximum depth attained during the treatment and a bottom time equal to or longer than the total elapsed time since treatment began. The Air/Oxygen schedule can be used even if gases other than air (i.e., nitrogen-oxygen or helium-oxygen mixtures) were breathed at depth.

If death occurs after leaving the initial treatment depth on Treatment Tables 6 or 6A, decompress the tenders at 30 fsw/min to 30 fsw and have them breathe oxygen at 30 fsw for the times indicated in Table 4.1. Following completion of the oxygen breathing time at 30 fsw, decompress the tenders on oxygen from 30 fsw to the surface at 1 fsw/min.

If death occurs after leaving the initial treatment depth on Treatment Tables 4 or 8, or after beginning treatment on Treatment Table 7 at 60 fsw, have the tenders decompress by continuing on the treatment table as written, or consult NEDU for a decompression schedule customized for the situation at hand. If neither option is possible, follow the original treatment table to 60 fsw. At 60 fsw, have the tenders breathe oxygen for 90 min in three 30-min periods separated by a 5-min air break. Continue decompression at 50, 40 and 30 fsw by breathing oxygen for 60 min at each depth. Ascend between stops at 30 fsw/ min. At 50 fsw, breathe oxygen in two 30-min periods separated by a 5-min air break. At 40 and 30 fsw, breathe oxygen for the full 60-min period followed by a 15- min air break. Ascend to 20 fsw at 30 fsw/min and breathe oxygen for 120 min. Divide the oxygen time at 20 fsw into two 60-min periods separated by a 15 min air break.

When oxygen breathing time is complete at 20 fsw, ascend to the surface at 30 fsw/min. Upon surfacing, observe the tenders carefully for the occurrence of decompression sickness.

4.7.2 Impending Natural Disasters or Mechanical Failures

Impending natural disasters or mechanical failures may force the treatment to be aborted. For instance, the ship where the chamber is located may be in imminent danger of sinking or a fire or explosion may have severely damaged the chamber system to such an extent that completing the treatment is impossible. In these cases, the abort procedure described in section 4.7.1 could be used for all chamber occupants (including the stricken diver) if time is available. If time is not available, the following may be done:

A. If deeper than 60 feet, go immediately to 60 feet.

B. Once the chamber is 60 feet or shallower, put all chamber occupants on continuous 100 percent oxygen. Select the Air/Oxygen schedule in the Air Decompression Table corresponding to the maximum depth attained during treatment and the total elapsed time since treatment began.

C. If at 60 fsw, breathe oxygen for period of time equal to the sum of all the decompression stops 60 fsw and deeper in the Air/Oxygen schedule, then continue decompression on the Air/Oxygen schedule, breathing oxygen continuously. If shallower than 60 fsw, breathe oxygen for a period of time equal to the sum of all the decompression stops deeper than the divers current depth, then continue decompression on the Air/Oxygen schedule, breathing oxygen continuously. Complete as much of the Air/Oxygen schedule as possible.

D. When no more time is available, bring all chamber occupants to the surface (try not to exceed 10 feet per minute) and keep them on 100 percent oxygen during evacuation, if possible. Immediately evacuate all chamber occupants to the nearest recompression facility and treat according to flow chart 1 in appendix 2. If no symptoms occurred after the treatment was aborted, follow Treatment Table 6.

Appendix 1: NOAA Chamber Kit Inventory

Primary Kit

General Items

- DMT Neuro exam guide Pen
- Personal protective gloves (5)
- Eye protection
- Pocket mask
- Tongue depressors
- Oropharyngeal airways
- Nasal airways

Diagnostics/tools

- Blood pressure cuff
- Stethoscope
- Pen lights
- Thermometer – digital (NO mercury)
- Scissors (EMT shears)
- Reflex hammer
- Wartenberg Neuro Wheel
- Hemostat
- Tweezers
- Otoscope
- Tuning fork
- Pulse oximeter

Dressing pack

- Band aids (various types)
- 1" tape (1)
- ¾" waterproof tape (1)
- Cotton tip applicators – sterile (5)
- Antiseptic Cleansing Wipes (4)

Secondary Kit

General Supplies

- Hand powered suction device
- Foley cath kit
- NG tube
- 60cc Syringe
- Bag-valve-Mask
- Large-bore catheter on a needle (12 or 14 gauge) for cricothyrotomy or relief of tension pneumothorax (or alternatively, pre-packaged tension pneumothorax kit or cricothyrotomy kit such as QuickTrach™)
- BD Bard Parker Heimlich Chest Drain Valve (or other device to provide one-way flow of gas out of the chest

Drug Pack

- Ibuprofen Tablets, 200mg (4)
- Acetaminophen 500mg (4)
- Diphenhydramine 25 mg (3)
- Antacids
- Lidocaine 100mg/5ml
- Lovenox 30 mg (2)

Dressing Pack 2

- Gauze 2X2s (5)
- Gauze 4X4 dressings (5)
- Non-stick (Telfa) dressings (3)
- Kerlix 4" roll (2)
- Guaze 2" roller bandage (2)
- Guaze 4" roller bandage (2)
- 1" tape (2)
- Bandage scissors
- Povodine-Iodine Wipes (6)
- 20cc syringe for irrigation
- 250 cc NS for irrigation

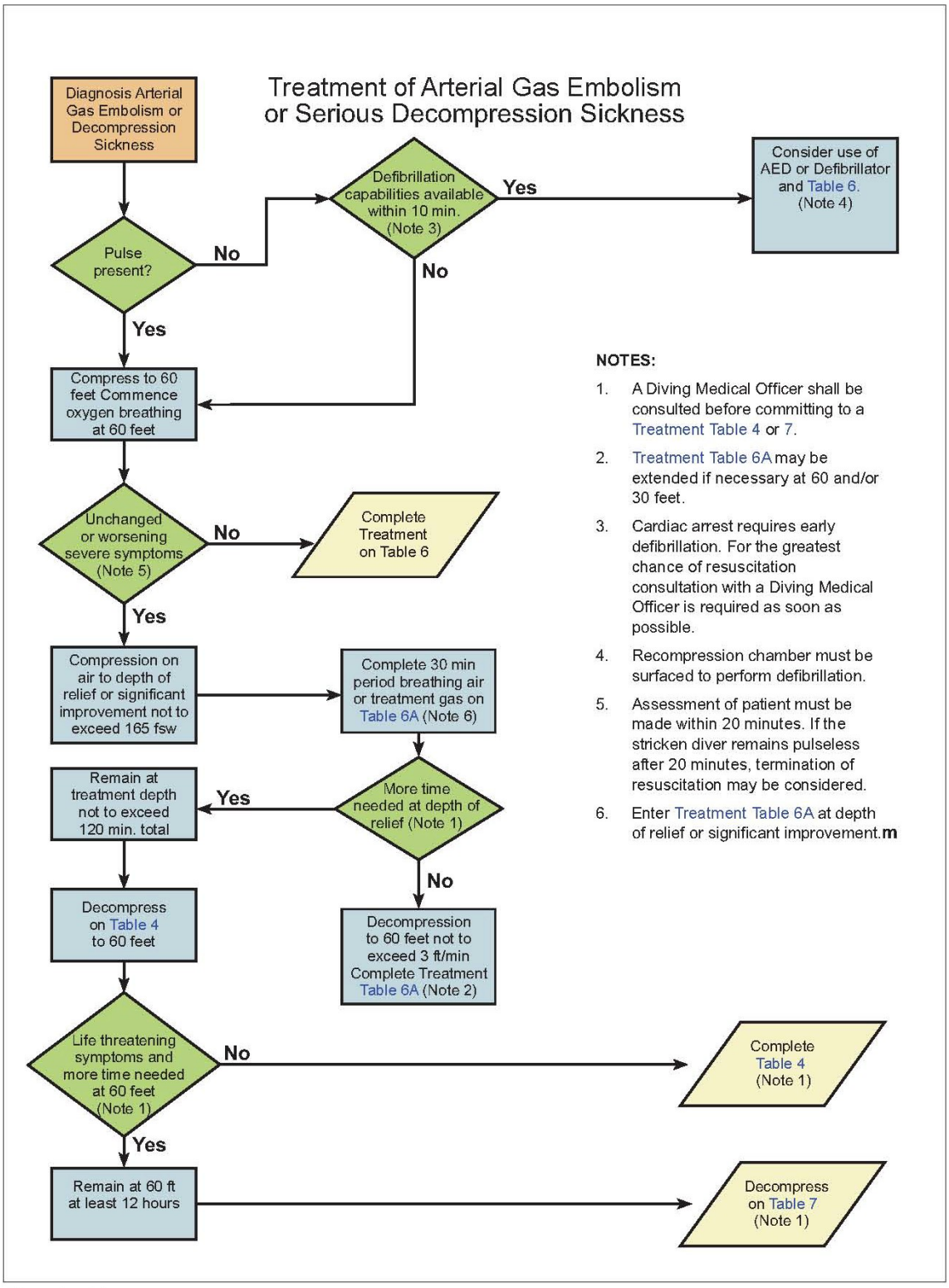
Orthopedic Pack

- Triangular bandages (2)
- 2" cloth tape (1 roll)
- 4" Ace wrap (1)

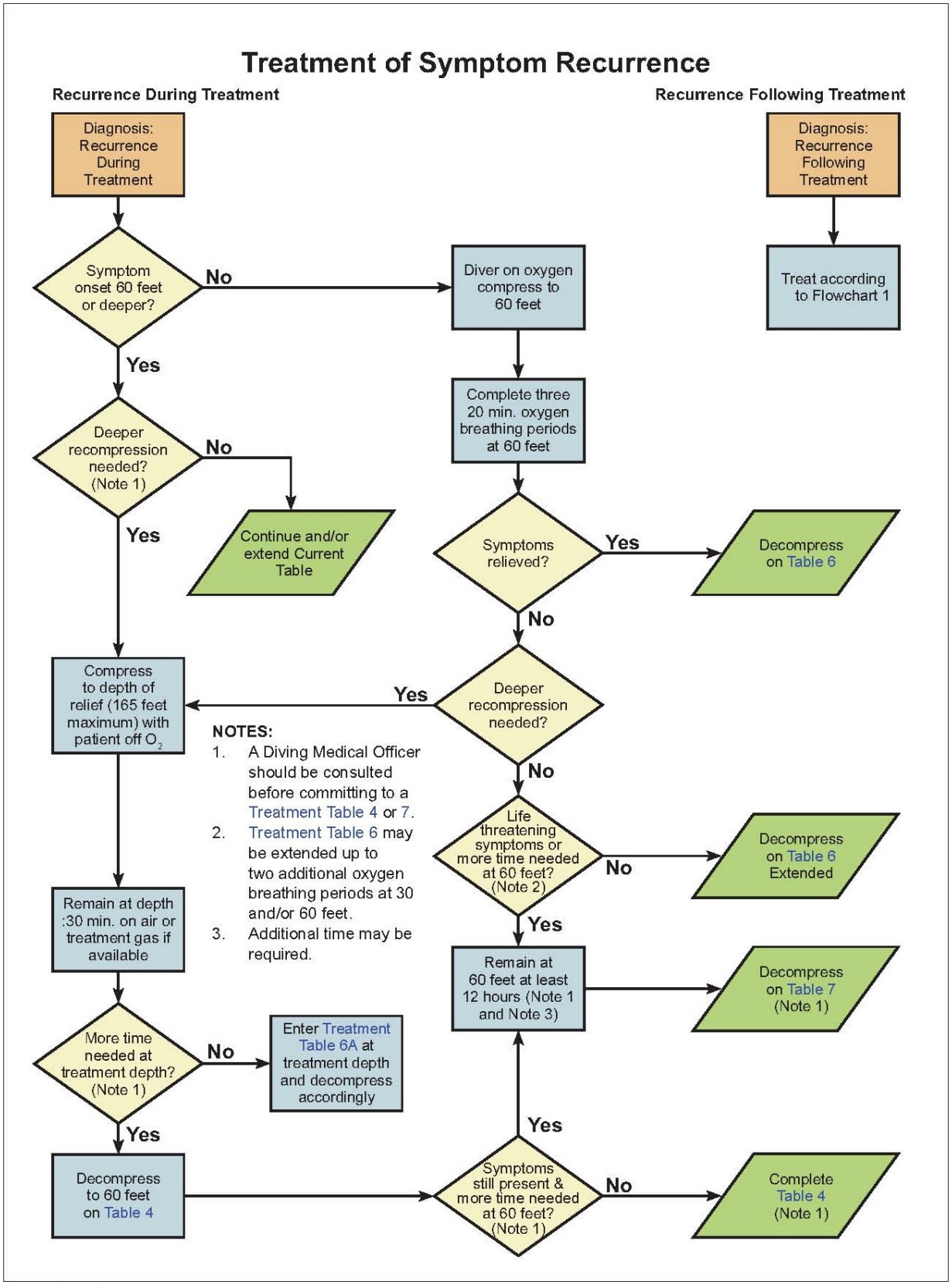
IV Kit

- 1000cc bag LR
- IV drip set
- IV extension tubing
- IV caths (16, 18, & 20g)
- Tourniquet
- 3cc syringes (3)
- Pressure bag
- Opsite or equivalent IV dressing

Appendix 2: Flowcharts

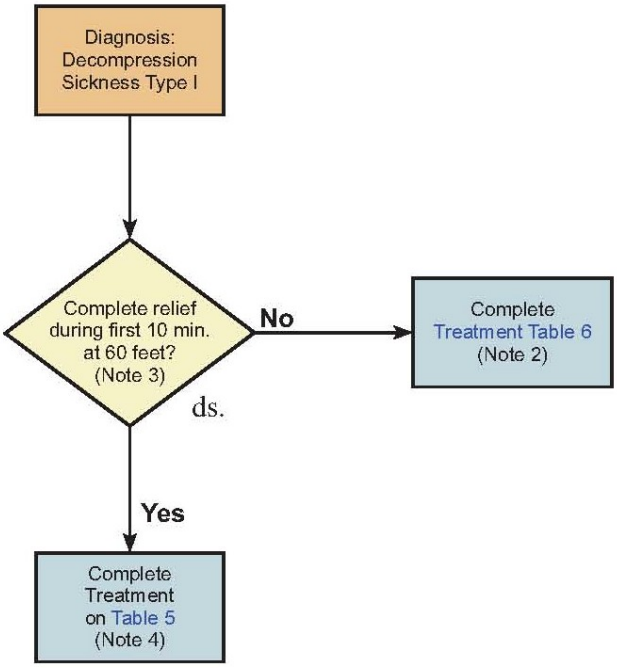


Flowchart 1


Treatment of Symptom Recurrence
Recurrence During Treatment
Recurrence Following Treatment
Diagnosis: Recurrence During Treatment
Diagnosis: Recurrence Following Treatment
Symptom onset 60 feet or deeper?
No
Yes
Diver on oxygen compress to 60 feet
Treat according to Flowchart 1
Deeper recompression needed? (Note 1)
No
Yes
Continue and/or extend Current Table
Complete three 20 min. oxygen breathing periods at 60 feet
Symptoms relieved?
Yes
Decompress on Table 6
No
Compress to depth of relief (165 feet maximum) with patient off O2
Yes
Deeper recompression needed?
No
NOTES:
1. A Diving Medical Officer should be consulted before committing to a Treatment Table 4 or 7.
2. Treatment Table 6 may be extended up to two additional oxygen breathing periods at 30 and/or 60 feet.
3. Additional time may be required.
Life threatening symptoms or more time needed at 60 feet? (Note 2)
No
Decompress on Table 6 Extended
Yes
Remain at depth :30 min. on air or treatment gas if available
Remain at 60 feet at least 12 hours (Note 1 and Note 3)
Decompress on Table 7 (Note 1)
More time needed at treatment depth? (Note 1)
No
Enter Treatment Table 6A at treatment depth and decompress accordingly
Yes
Yes
Decompress to 60 feet on Table 4
Symptoms still present & more time needed at 60 feet? (Note 1)
No
Complete Table 4 (Note 1)

Flowchart 2

Treatment of Type I Decompression Sickness



NOTES:

1. If a complete neurological exam was not completed before recompression, treat as a Type II symptom.
2. Treatment Table 6 may be extended up to four additional oxygen-breathing periods, two at 30 feet and/or two at 60 feet.
3. Diving Supervisor may elect to treat on Treatment Table 6.
4. Treatment Table 5 may be extended two oxygen-breathing periods at 30 fsw.

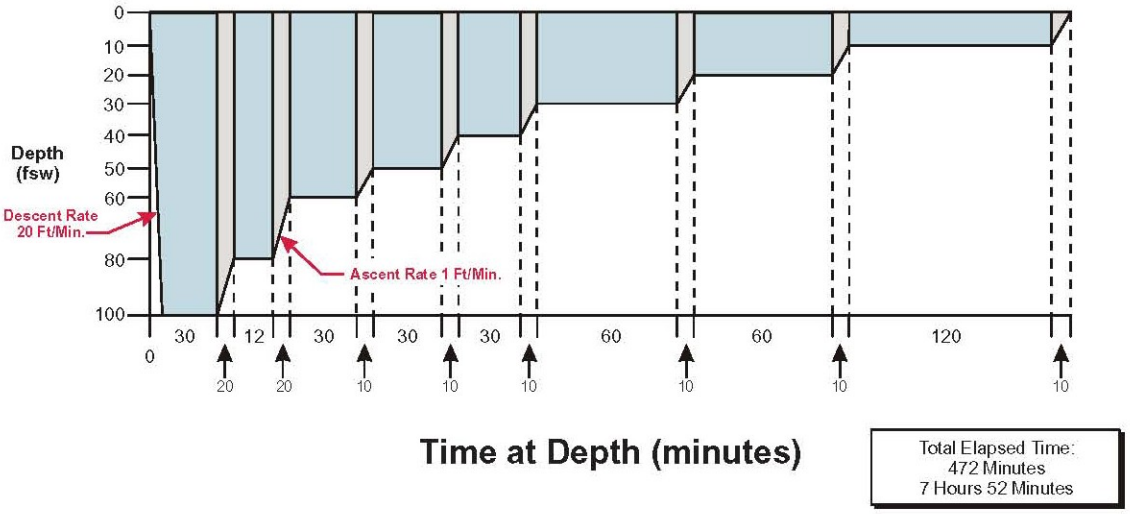
Flowchart 3

Appendix 3: Treatment Tables

Air Treatment Table 1A

1. Descent rate - 20 ft/min.
2. Ascent rate - 1 ft/min.
3. Time at 100 feet includes time from the surface.

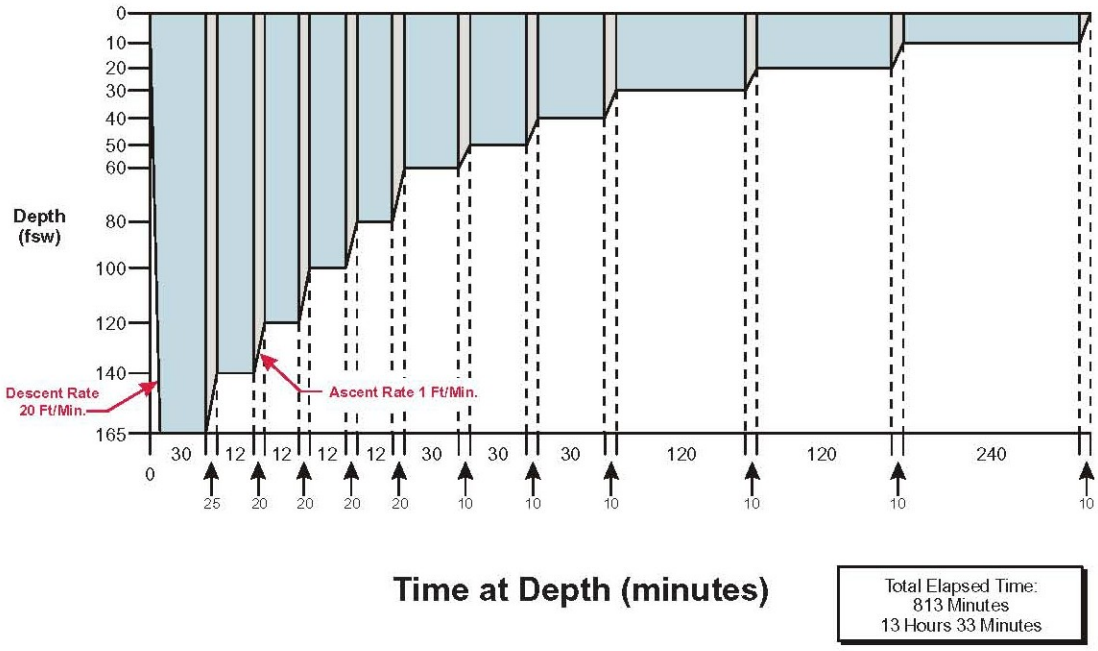
Treatment Table 1A Depth/Time Profile



Air Treatment Table 2A

1. Descent rate - 20 ft/min.
2. Ascent rate - 1 ft/min.
3. Time at 165 feet includes time from the surface.

Treatment Table 2A Depth/Time Profile



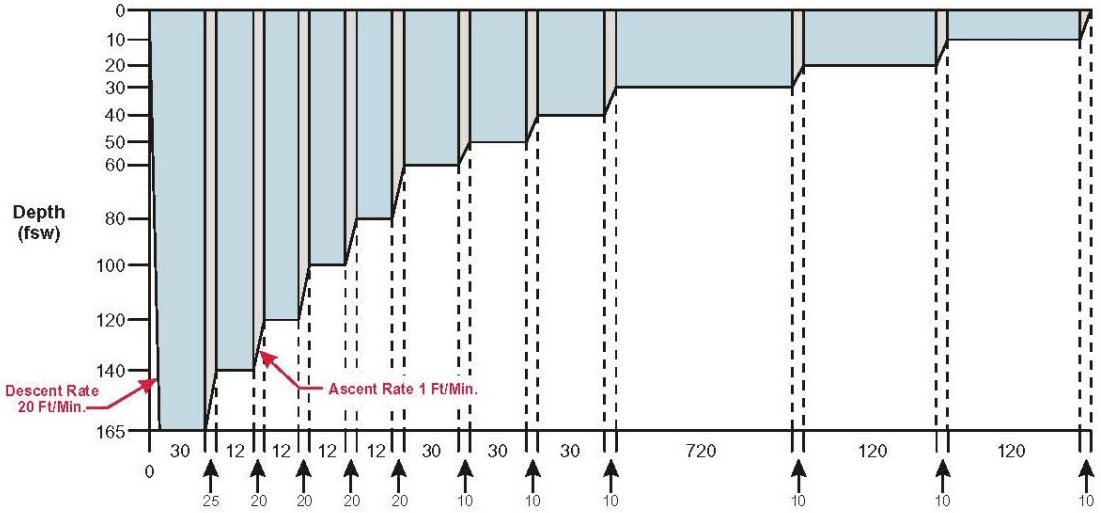
Time at Depth (minutes)

Total Elapsed Time:
813 Minutes
13 Hours 33 Minutes

Air Treatment Table 3

1. Descent rate - 20 ft/min.
2. Ascent rate - 1 ft/min.
3. Time at 165 feet-includes time from the surface.

Treatment Table 3 Depth/Time Profile



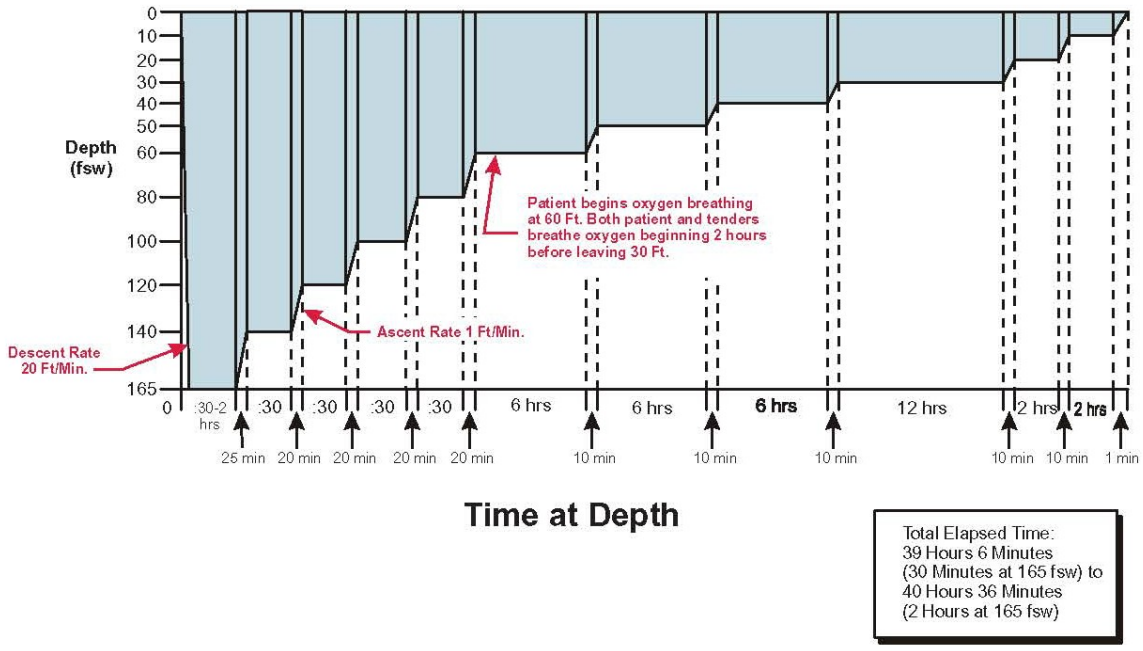
Time at Depth (minutes)

Total Elapsed Time:
1293 Minutes
21 Hours 33 Minutes

Treatment Table 4

1. Descent rate - 20 ft/min.
2. Ascent rate - 1 ft/min.
3. Time at 165 feet includes compression.
4. If only air is available, decompress on air. If oxygen is available, patient begins oxygen breathing upon arrival at 60 feet with appropriate air breaks. Both tender and patient breathe oxygen beginning 2 hours before leaving 30 feet. (see paragraph 20-5.5).
5. Ensure life-support considerations can be met before committing to a Table 4. (see paragraph 20-7.5) Internal chamber temperature should be below 85° F.
6. If oxygen breathing is interrupted, no compensatory lengthening of the table is required.
7. If switching from Treatment Table 6A or 3 at 165 feet, stay a maximum of 2 hours at 165 feet before decompressing.
8. If the chamber is equipped with a high-O_2 treatment gas, it may be administered at 165 fsw, not to exceed 3.0 ata O_2. Treatment gas is administered for 25 minutes interrupted by 5 minutes of air.

Treatment Table 4 Depth/Time Profile

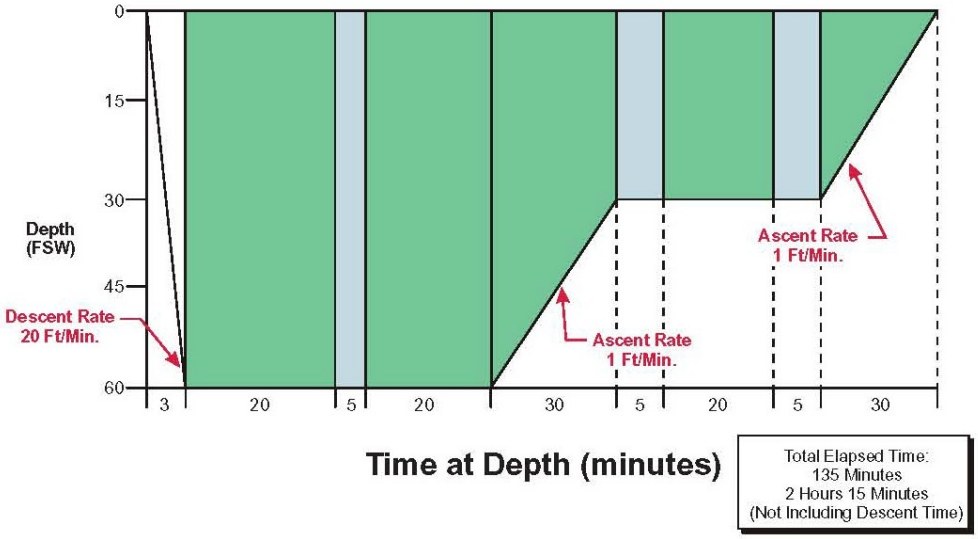


Total Elapsed Time:
39 Hours 6 Minutes
(30 Minutes at 165 fsw) to
40 Hours 36 Minutes
(2 Hours at 165 fsw)

Treatment Table 5

1. Descent rate - 20 ft/min.
2. Ascent rate - Not to exceed 1 ft/min. Do not compensate for slower ascent rates. Compensate for faster rates by halting the ascent.
3. Time on oxygen begins on arrival at 60 feet.
4. If oxygen breathing must be interrupted because of CNS Oxygen Toxicity, allow 15 minutes after the reaction has entirely subsided and resume schedule at point of interruption (see paragraph 20-7.11.1.1)
5. Treatment Table may be extended two oxygen-breathing periods at the 30-foot stop. No air break required between oxygen-breathing periods or prior to ascent.
6. Tender breathes 100 percent O_2 during ascent from the 30-foot stop to the surface. If the tender had a previous hyperbaric exposure in the previous 18 hours, an additional 20 minutes of oxygen breathing is required prior to ascent.

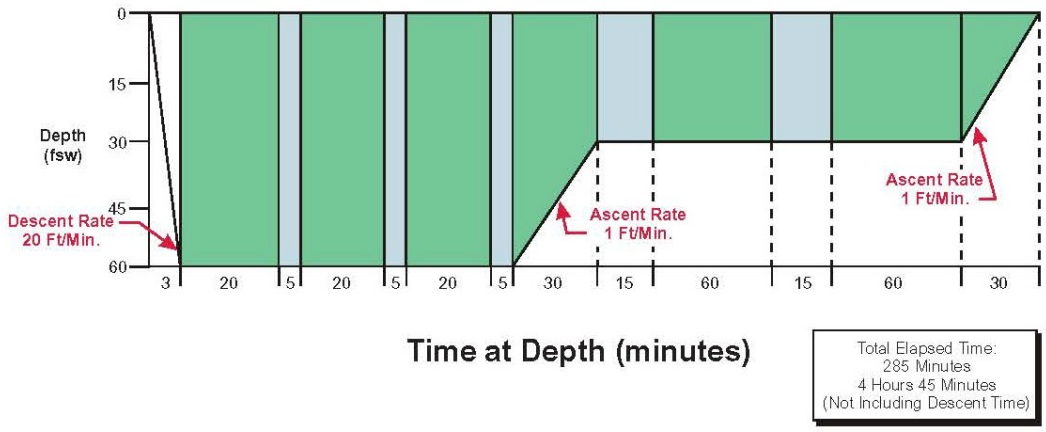
Treatment Table 5 Depth/Time Profile



Treatment Table 6

1. Descent rate - 20 ft/min.
2. Ascent rate - Not to exceed 1 ft/min. Do not compensate for slower ascent rates. Compensate for faster rates by halting the ascent.
3. Time on oxygen begins on arrival at 60 feet.
4. If oxygen breathing must be interrupted because of CNS Oxygen Toxicity, allow 15 minutes after the reaction has entirely subsided and resume schedule at point of interruption (see paragraph 20-7.11.1.1).
5. Table 6 can be lengthened up to 2 additional 25-minute periods at 60 feet (20 minutes on oxygen and 5 minutes on air), or up to 2 additional 75-minute periods at 30 feet (15 minutes on air and 60 minutes on oxygen), or both.
6. Tender breathes 100 percent O_2 during the last 30 min. at 30 fsw and during ascent to the surface for an unmodified table or where there has been only a single extension at 30 or 60 feet. If there has been more than one extension, the O_2 breathing at 30 feet is increased to 60 minutes. If the tender had a hyperbaric exposure within the past 18 hours an additional 60-minute O_2 period is taken at 30 feet.

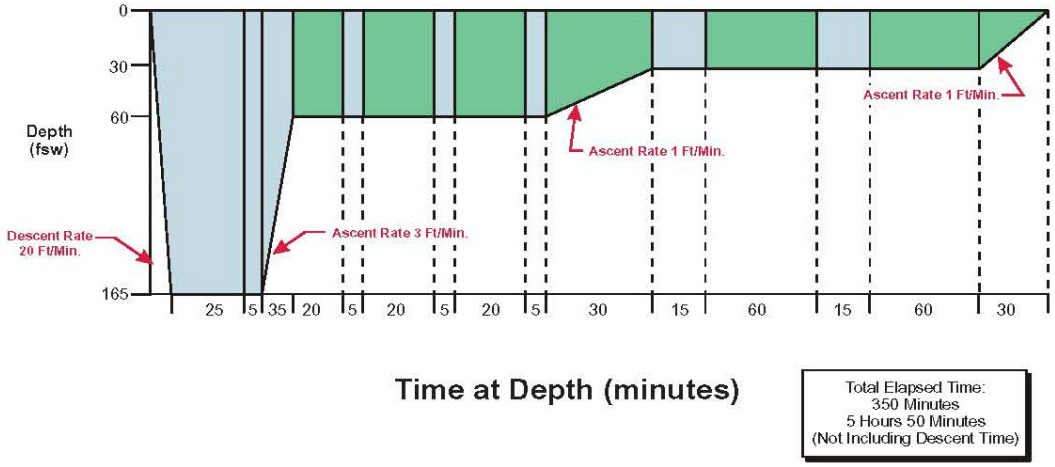
Treatment Table 6 Depth/Time Profile



Treatment Table 6A

1. Descent rate - 20 ft/min.
2. Ascent rate - 165 fsw to 60 fsw not to exceed 3 ft/min, 60 fsw and shallower, not to exceed 1 ft/min. Do not compensate for slower ascent rates. Compensate for faster rates by halting the ascent.
3. Time at treatment depth does not include compression time.
4. Table begins with initial compression to depth of 60 fsw. If initial treatment was at 60 feet, up to 20 minutes may be spent at 60 feet before compression to 165 fsw. Contact a Diving Medical Officer.
5. If a chamber is equipped with a high-O_2 treatment gas, it may be administered at 165 fsw and shallower, not to exceed 3.0 ata O_2 in accordance with paragraph 20-7.10. Treatment gas is administered for 25 minutes interrupted by 5 minutes of air. Treatment gas is breathed during ascent from the treatment depth to 60 fsw.
6. Deeper than 60 feet, if treatment gas must be interrupted because of CNS oxygen toxicity, allow 15 minutes after the reaction has entirely subsided before resuming treatment gas. The time off treatment gas is counted as part of the time at treatment depth. If at 60 feet or shallower and oxygen breathing must be interrupted because of CNS oxygen toxicity, allow 15 minutes after the reaction has entirely subsided and resume schedule at point of interruption (see paragraph 20-7.11.1.1).
7. Table 6A can be lengthened up to 2 additional 25-minute periods at 60 feet (20 minutes on oxygen and 5 minutes on air), or up to 2 additional 75-minute periods at 30 feet (60 minutes on oxygen and 15 minutes on air), or both.
8. Tender breathes 100 percent O_2 during the last 60 minutes at 30 fsw and during ascent to the surface for an unmodified table or where there has been only a single extension at 30 or 60 fsw. If there has been more than one extension, the O_2 breathing at 30 fsw is increased to 90 minutes. If the tender had a hyperbaric exposure within the past 18 hours, an additional 60 minute O_2 breathing period is taken at 30 fsw.
9. If significant improvement is not obtained within 30 minutes at 165 feet, consult with a Diving Medical Officer before switching to Treatment Table 4.

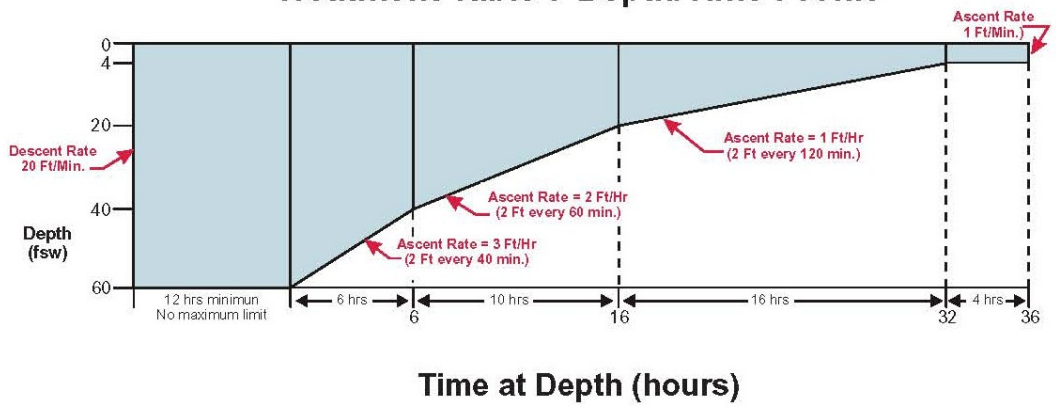
Treatment Table 6A Depth/Time Profile



Treatment Table 7

1. Table begins upon arrival at 60 feet. Arrival at 60 feet is accomplished by initial treatment on Table 6, 6A or 4. If initial treatment has progressed to a depth shallower than 60 feet, compress to 60 feet at 20 ft/min to begin Table 7.
2. Maximum duration at 60 feet is unlimited. Remain at 60 feet a minimum of 12 hours unless overriding circumstances dictate earlier decompression.
3. Patient begins oxygen breathing periods at 60 feet. Tender need breathe only chamber atmosphere throughout. If oxygen breathing is interrupted, no lengthening of the table is required.
4. Minimum chamber O_2 concentration is 19 percent. Maximum CO_2 concentration is 1.5 percent SEV (11.4 mmHg). Maximum chamber internal temperature is 85°F (paragraph 20-7.5).
5. Decompression starts with a 2-foot upward excursion from 60 to 58 feet. Decompress with stops every 2 feet for times shown in profile below. Ascent time between stops is approximately 30 seconds. Stop time begins with ascent from deeper to next shallower step. Stop at 4 feet for 4 hours and then ascend to the surface at 1 ft/min.
6. Ensure chamber life-support requirements can be met before committing to a Treatment Table 7.
7. A Diving Medical Officer should be consulted before committing to this treatment table.

Treatment Table 7 Depth/Time Profile



Time at Depth (hours)

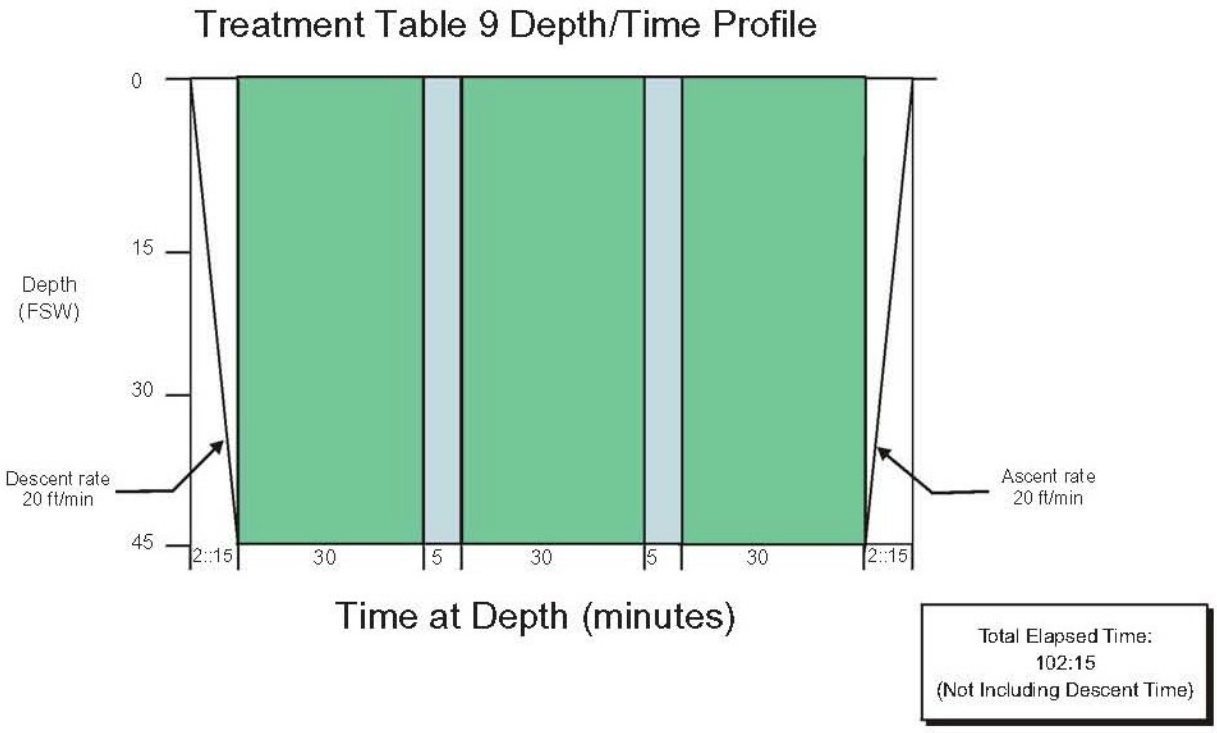
Treatment Table 8

1. Enter the table at the depth which is exactly equal to or next greater than the deepest depth attained in the recompression. The descent rate is as fast as tolerable.
2. The maximum time that can be spent at the deepest depth is shown in the second column. The maximum time for 225 fsw is 30 minutes; for 165 fsw, 3 hours. For an asymptomatic diver, the maximum time at depth is 30 minutes for depths exceeding 165 fsw and 2 hours for depths equal to or shallower than 165 fsw.
3. Decompression is begun with a 2-fsw reduction in pressure if the depth is an even number. Decompression is begun with a 3-fsw reduction in pressure if the depth is an odd number. Subsequent stops are carried out every 2 fsw. Stop times are given in column three. The stop time begins when leaving the previous depth. Ascend to the next stop in approximately 30 seconds.
4. Stop times apply to all stops within the band up to the next quoted depth. For example, for ascent from 165 fsw, stops for 12 minutes are made at 162 fsw and at every two-foot interval to 140 fsw. At 140 fsw, the stop time becomes 15 minutes. When traveling from 225 fsw, the 166-foot stop is 5 minutes; the 164-foot stop is 12 minutes. Once begun, decompression is continuous. For example, when decompressing from 225 feet, ascent is not halted at 165 fsw for 3 hours. However, ascent may be halted at 60 fsw and shallower for any desired period of time.
5. While deeper than 165 fsw, a helium-oxygen mixture with 16-36 percent oxygen may be breathed by mask to reduce narcosis. A 64/36 helium-oxygen mixture is the preferred treatment gas. At 165 fsw and shallower, a HeO_2 or N_2O_2 mix with a ppO_2 not to exceed 3.0 ata may be given to the diver as a treatment gas. At 60 fsw and shallower, pure oxygen may be given to the divers as a treatment gas. For all treatment gases (HeO_2, N_2O_2, and O_2), a schedule of 25 minutes on gas and 5 minutes on chamber air should be followed for a total of four cycles. Additional oxygen may be given at 60 fsw after a 2-hour interval of chamber air. See Treatment Table 7 for guidance. If high O_2 breathing is interrupted, no lengthening of the table is required.
6. To avoid loss of the chamber seal, ascent may be halted at 4 fsw and the total remaining stop time of 240 minutes taken at this depth. Ascend directly to the surface upon completion of the required time.
7. Total ascent time from 225 fsw is 56 hours, 29 minutes. For a 165-fsw recompression, total ascent time is 53 hours, 52 minutes, and for a 60-fsw recompression, 36 hours, 0 minutes.

Depth (fsw)	Max Time at Initial Treatment Depth (hours)	2-fsw Stop Times (minutes)
225	0.5	5
165	3	12
140	5	15
120	8	20
100	11	25
80	15	30
60	Unlimited	40
40	Unlimited	60
20	Unlimited	120

Treatment Table 9

1. Descent rate - 20 ft/min.
2. Ascent rate - 20 ft/min. Rate may be slowed to 1 ft/min depending upon the patient's medical condition.
3. Time at 45 feet begins on arrival at 45 feet.
4. If oxygen breathing must be interrupted because of CNS Oxygen Toxicity, oxygen breathing may be restarted 15 minutes after all symptoms have subsided. Resume schedule at point of interruption (see paragraph 20-7.11.1.1).
5. Tender breathes 100 percent O_2 during last 15 minutes at 45 feet and during ascent to the surface regardless of ascent rate used.
6. Patient may breathe air or oxygen during ascent.
7. If patient cannot tolerate oxygen at 45 feet, this table can be modified to allow a treatment depth of 30 feet. The oxygen breathing time can be extended to a maximum of 3 to 4 hours.



Appendix 4: Recompression Chamber Pre-Dive Checklist

RECOMPRESSION CHAMBER PRE-DIVE CHECKLIST	
Equipment	**Initials**
CHAMBER	
Clean	
Free of all extraneous equipment	
Free of noxious odors	
Doors and seals undamaged and seals lubricated	
Pressure gauges calibrated compared	
AIR SUPPLY SYSTEM	
Air quality test is current	
Primary supply adequate for two pressurizations to 165 fsw plus ventilations.	
Secondary supply adequate for one pressurization to 165 fsw and one hour of ventilation.	
Supply valve(s) closed	
Equalization valve closed	
Supply valve(s) Closed	
Equalization valve closed if applicable	
Supply regulator set at 200 psi maximum	
Fittings tight	
Compressor oil checked, adequate ventilation, intake is free of contaminants	
EXHAUST SYSTEM	
Terminates clear of chamber	
Exhaust valve closed	
Overpressure relief valve(s) calibrated and upstream valve open	
OXYGEN SUPPLY SYSTEM	
Cylinders full, marked as breathing oxygen, cylinder valves open	
Replacement cylinders on hand	
BIBS masks installed and functioning (120 osig)	
Gauges calibrated and fittings tight	
Oxygen manifold valves closed to BIBS	
Over-board dump valves closed	
RECOMPRESSION CHAMBER PRE-DIVE CHECKLIST	
Equipment	**Initials**
AIR BIBS SYSTEM	
Cylinders full, cylinder valves open	
Replacement cylinder on hand	
BIBS mask installed and functioning	
Regulator set 90 psig over-bottom pressure	
Gauges calibrated and fittings tight	
Air valves closed to BIBS	

ELECTRICAL SYSTEM	
Lights operational	
Wiring approved and properly grounded	
Oxygen analyzer functioning and calibrated	
Video operational	
Electrical power to compressor(s) checked	
Emergency power checked and adequate	
COMMUNICATION SYSTEM	
Primary system operational	
Secondary system operational	
Spare batteries	
Phone with outside connection capabilities (hard-wired or cell)	
FIRE PREVENTION SYSTEM	
Water bucket w/towel and/or appropriate fire extinguisher in chamber	
Fire resistant or NOAA approved clothing worn by all chamber occupants	
Fire resistant or NOAA approved mattresses, pillow and blankets in chamber	
MISCELLANEOUS	
Inside Chamber:	
Hearing protection	
Oxygen resuscitator w/positive pressure demand valve	
Appropriate chamber training medical kit ready (if applicable)	

RECOMPRESSION CHAMBER PRE-DIVE CHECKLIST	
Equipment	**Initials**
MISCELLANEOUS (CONT.)	
Outside Chamber:	
Chamber log with time sheets	
List of emergency phone numbers	
Neurological exam check off sheet	
Checklist for secondary assessment of injury(s)	
U.S. Navy standard air decompression tables	
Writing utensils- pen, pencil, paper	
Mallet	
U.S. Navy Treatment Tables	
Stop Watches	
Spare Air and Oxygen BIBS Masks	
Flashlight	
Hearing Protection	
Spare hatch o-rings	

Name _____

Signature _____ Date _____

Appendix 5: Recompression Chamber Post-Dive Checklist

RECOMPRESSION CHAMBER POST-DIVE CHECKLIST	
Equipment	**Initials**
Chamber	
Remove all necessary and unnecessary support items from chamber	
Wipe clean with non-ionic detergent and warm water	
Clean and replace blankets	
Pour out water bucket (if used), dry and replace in chamber	
Air out chamber	
Replace all necessary support items (BIBs, medical kit, hearing protection etc…)	
Check viewports for damage, replace if necessary	
Inspect door seals, replace if necessary	
Close and seal outer lock door	
AIR SUPPLY SYSTEM	
Close all chamber supply valves	
Fill and record gauge pressure of air banks	
Close air cylinder valves	
Service compressors per manufacturers technical manual	
EXHAUST SYSTEM	
Ensure chamber exhaust valves are in open position	
OXYGEN SUPPLY SYSTEM	
Clean BIBS masks, dry, test and replace as necessary	
Close oxygen cylinder valves	
Bleed oxygen from system	
Close all chamber oxygen supply valves	
Replace oxygen cylinders as required	
Ensure spare oxygen cylinders are available	
AIR BIBS SYSTEM	
Remove and clean Scott air masks if used and replace	

RECOMPRESSION CHAMBER POST-DIVE CHECKLIST	
Equipment	**Initials**
ELECTRICAL SYSTEM	
Check all circuits operating	
Replace light bulbs as necessary	
If lights are placed in a pressure proof housing, check for damage and replace if necessary	
Check all wiring for fraying	

COMMUNICATION SYSTEM	
Test and secure primary and secondary comm. system and repair as necessary	
FIRE PREVENTION SYSTEM	
Check fire extinguisher still full and fill if necessary	
MISCELLANEOUS	
Outside Chamber:	
Chamber log completed and returned to chamber	
Backboard cleaned and returned to chamber	

Name _____

Signature _____ Date _____

Appendix 6: U.S. Navy Diving Manual – Chapter 20 (volume 5)

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CHAPTER 20

Diagnosis and Treatment of Decompression Sickness and Arterial Gas Embolism

20-1 INTRODUCTION

20-1.1 Purpose. This chapter describes the diagnosis and treatment of diving disorders with recompression therapy and/or hyperbaric oxygen therapy. Immediate recompression therapy is indicated for treating decompression sickness, arterial gas embolism and several other disorders. In those cases where diagnosis or treatment are not clear, contact the Diving Medical Officers at NEDU or NDSTC for clarification. The recompression procedures described in this chapter are designed to handle most situations that will be encountered operationally. They are applicable to both surface-supplied and open and closed circuit SCUBA diving as well as recompression chamber operations, whether on air, nitrogen-oxygen, helium- oxygen, or 100 percent oxygen. Treatment of decompression sickness during satu- ration dives is covered separately in Chapter 15 of this manual. Periodic evaluation of U.S. Navy recompression treatment procedures has shown they are effective in relieving symptoms over 10 percent of the time when used as published.

20-1.2 Scope. The procedures outlined in this chapter are to be performed only by trained personnel. Because these procedures cover disorders ranging from mild pain to life-threatening disorders, the degree of medical expertise necessary to carry out proper treatment will vary. Certain procedures, such as starting intravenous (IV) fluid lines and inserting chest tubes, require special training and must not be attempted by untrained individuals. Treatment tables can be initiated without consulting a Diving Medical Officer (DMO), however a DMO should always be contacted at the earliest possible opportunity. A DMO must be contacted prior to releasing the treated individual.

20-1.3 Diving Supervisor's Responsibilities. Experience has shown that symptoms of severe decompression sickness or arterial gas embolism may occur following seemingly uneventful dives within the prescribed limits. This fact, combined with the many operational scenarios under which diving is conducted, means that treatment of severely ill individuals will be required occasionally when qualified medical personnel are not immediately on scene. Therefore, it is the Diving Supervisor's responsibility to ensure that every member of the diving team:

- Is thoroughly familiar with all recompression procedures.
- Knows the location of the nearest, certified recompression facility.

- Knows how to contact a qualified Diving Medical Officer if one is not at the site.
- Has successfully completed Basic Life Support training.

20-1.4 Prescribing and Modifying Treatments. Because all possible outcomes cannot be anticipated, additional medical expertise should be sought immediately in all cases of decompression sickness or arterial gas embolism that do not show substantial improvement on standard treatment tables. Deviation from these protocols shall be made only with the recommendation of a Diving Medical Officer (DMO).

Not all Medical Officers are DMOs. The DMO shall be a graduate of the Diving Medical Officer course taught at the Naval Diving and Salvage Training Center (NDSTC) and have a subspecialty code of 16U0 (Basic Undersea Medical Officer) or 16U1 (Residency in Undersea Medicine trained Undersea Medical Officer). Medical Officers who complete only the nine-week diving medicine course at NDSTC do not receive DMO subspecialty codes, but are considered to have the same privileges as DMOs, with the exception that they are not granted the privilege of modifying treatment protocols. Only DMOs with subspecialty codes 16U0 or 16U1 may modify the treatment protocols as warranted by the patient's condition with the concurrence of the Commanding Officer or Officer in Charge. Other physicians may assist and advise treatment and care of diving casualties but may not modify recompression procedures.

20-1.5 When Treatment is Not Necessary. If the reason for postdive symptoms is firmly established to be due to causes other than decompression sickness or arterial gas embolism (e.g. injury, sprain, poorly fitting equipment), then recompression is not necessary. If the diving supervisor cannot rule out the need for recompression then commence treatment.

20-1.6 Emergency Consultation. Modern communications allow access to medical expertise from even the most remote areas. Emergency consultation is available 24 hours a day with:

Primary:
Navy Experimental Diving Unit (NEDU)
Commercial (850) 230-3100 or (850) 235-1668, DSN 436-4351

Secondary:
Navy Diving Salvage and Training Center (NDSTC)
Commercial (850) 234-4651, DSN 436-4651

20-2 ARTERIAL GAS EMBOLISM

Arterial gas embolism is caused by entry of gas bubbles into the arterial circulation as a result of pulmonary over inflation syndrome (POIS). Gas embolism can manifest during any dive where breaths are taken utilizing underwater breathing equipment, even a brief, shallow dive, or one made in a swimming pool. The onset of symptoms is usually sudden and dramatic, often occurring within minutes after arrival on the surface or even before reaching the surface. Because the supply of blood to the central nervous system is almost always compromised, arterial gas embolism may result in death or permanent neurological damage unless treated with immediate recompression.

20-2.1 Diagnosis of Arterial Gas Embolism. As a basic rule, any diver who has obtained a breath of compressed gas from any source at depth, whether from diving apparatus or from a diving bell, and who surfaces unconscious, loses consciousness, or has any obvious neurological symptoms within 10 minutes of reaching the surface, must be assumed to be suffering from arterial gas embolism. Recompression treatment shall be started immediately. A diver who surfaces unconscious and recovers when exposed to fresh air shall receive a neurological evaluation to rule out arterial gas embolism. Victims of near-drowning who have no neurological symptoms should be carefully evaluated by a DMO for pulmonary aspiration.

The symptoms of AGE may be masked by environmental factors or by other less significant symptoms. A chilled diver may not be concerned with numbness in an arm, which may actually be the sign of CNS involvement. 0ain from any source may divert attention from other symptoms. The natural anxiety that accompanies an emergency situation, such as the failure of the diver's air supply, might mask a state of confusion caused by an arterial gas embolism to the brain.

If pain is the only symptom, arterial gas embolism is unlikely and decompression sickness or one of the other pulmonary overinflation syndromes should be considered.

20-2.1.1 **Symptoms of AGE.** The signs and symptoms of AGE may include near immediate onset of dizziness, paralysis or weakness in the extremities, large areas of abnormal sensation (paresthesias), vision abnormalities, convulsions or personality changes. During ascent, the diver may have noticed a sensation similar to that of a blow to the chest. The victim may become unconscious without warning and may stop breathing. Additional symptoms of AGE include:

- Extreme fatigue
- Difficulty in thinking
- Vertigo
- Nausea and/or vomiting
- Hearing abnormalities
- Bloody sputum
- Loss of control of bodily functions
- Tremors

- Loss of coordination
- Numbness

Symptoms of subcutaneous / mediastinal emphysema, pneumothorax and/or pneumopericardium may also be present (see paragraph 3-8). In all cases of arterial gas embolism, the possible presence of these associated conditions should not be overlooked.

20-2.2 Treating Arterial Gas Embolism. Arterial gas embolism is treated in accordance with Figure 20-1 with initial compression to 60 fsw. If symptoms are improved within the first oxygen breathing period, then treatment is continued using Treatment Table 6. If symptoms are unchanged or worsen, assess the patient upon descent and compress to depth of relief (or significant improvement), not to exceed 165 fsw and follow Figure 20-1.

20-2.3 Resuscitation of a Pulseless Diver. The following are intended as guidelines. For a diver with no pulse or respirations (cardiopulmonary arrest) immediate cardiopulmonary resuscitation (CPR) and use of the Automated External Defibrillator (AED) is a higher priority than recompression. Advanced cardiac life support (ACLS), which requires special medical training and equipment, is not always available. CPR, patient monitoring, and drug administration may be able to be performed at depth, but electrical therapy (defibrillation and cardioversion) **must** be performed on the surface.

CAUTION Defibrillation is not currently authorized at depth.

If a qualified provider with the necessary equipment (i.e., AED) can administer the potentially lifesaving therapies within 10 minutes, the stricken diver should be kept at the surface until a pulse is obtained. Unless defibrillation is administered within 10 minutes, the diver likely will die, even if adequate CPR is performed, with or without recompression. If defibrillation is not available and a Diving Medical Officer (DMO) is not present, the Diving Supervisor should compress the diver to 60 feet and continue CPR and attempt to contact a DMO.

If defibrillation becomes available within 20 minutes, the pulseless diver shall be brought to the surface at 30 fpm and defibrillated when appropriate on the surface. (Current data indicate that successful restoration of a perfusing rhythm after 20 minutes of cardiac arrest with only C0R is unlikely.) If the pulseless diver does not regain vital signs with defibrillation, continue CPR. Avoid **recompressing** a pulseless diver who has failed to regain vital signs after defibrillation. Resuscitation efforts shall continue until the diver recovers, the tenders are unable to continue CPR, or a physician pronounces the patient dead. If the pulseless diver does regain vital signs, proceed with recompression therapy if indicated.

CAUTION If the tender is outside of no-decompression limits, he should not be brought directly to the surface. Either take the decompression stops appropriate to the tender or lock in a new tender and decompress the patient and new tender to the surface in the outer lock, while maintaining the original tender at depth.

20-3 DECOMPRESSION SICKNESS

While a history of diving (or altitude exposure) is necessary for the diagnosis of decompression sickness to be made, the depth and duration of the dive are useful only in establishing if required decompression was missed. Decompression sickness can occur in divers well within no-decompression limits or in divers who have carefully followed decompression tables. Any decompression sickness that occurs must be treated by recompression.

For purposes of deciding the appropriate treatment, symptoms of decompression sickness are generally divided into two categories, Type I and Type II. Because the treatment of Type I and Type II symptoms may be different, it is important to distinguish between these two types of decompression sickness. The diver may exhibit certain signs that only trained observers will identify as decompression sickness. Some of the symptoms or signs will be so pronounced that there will be little doubt as to the cause. Others may be subtle and some of the more important signs could be overlooked in a cursory examination. Type I and Type II symptoms may or may not be present at the same time.

20-3.1 Diagnosis of Decompression Sickness. Decompression sickness symptoms usually occur shortly following the dive or other pressure exposure. If the controlled decompression during ascent has been shortened or omitted, the diver could be suffering from decompression sickness before reaching the surface. In analyzing several thousand air dives in a database set up by the U.S. Navy for developing decompression models, the time of onset of symptoms after surfacing was as follows:

- 42 percent occurred within 1 hour.
- 60 percent occurred within 3 hours.
- 83 percent occurred within 8 hours.
- 18 percent occurred within 24 hours.

Appendix 5A contains a set of guidelines for performing a neurological examination and an examination checklist to assist trained personnel in evaluating decompression sickness cases.

20-3.2 Symptoms of Type I Decompression Sickness. Type I decompression sickness includes joint pain (musculoskeletal or pain-only symptoms) and symptoms involving the skin (cutaneous symptoms), or swelling and pain in lymph nodes.

20-3.2.1 **Musculoskeletal Pain-Only Symptoms.** The most common symptom of decompression sickness is joint pain. Other types of pain may occur which do not involve joints. The pain may be mild or excruciating. The most common sites of joint pain are the shoulder, elbow, wrist, hand, knee, and ankle. The characteristic pain of Type I decompression sickness usually begins gradually, is slight when first noticed and may be difficult to localize. It may be located in a joint or muscle, may increase in intensity, and is usually described as a deep, dull ache. The pain may or may not be increased by movement of the affected joint, and the limb may be held preferentially in certain positions to reduce the intensity (so-called guarding). The hallmark of Type I pain is its dull, aching quality and confinement to particular areas. It is always present at rest and is usually unaffected by movement.

Any pain occurring in the abdominal and thoracic areas, including the hips, should be considered as symptoms arising from spinal cord involvement and treated as Type II decompression sickness. The following symptoms may indicate spinal cord involvement:

- Pain localized to joints between the ribs and spinal column or joints between the ribs and sternum.
- A shooting-type pain that radiates from the back around the body (radicular or girdle pain).
- A vague, aching pain in the chest or abdomen (visceral pain).

20-3.2.1.1 **Differentiating Between Type I Pain and Injury.** The most difficult differentiation is between the pain of Type I decompression sickness and the pain resulting from a muscle strain or bruise. If there is any doubt as to the cause of the pain, assume the diver is suffering from decompression sickness and treat accordingly. Frequently, pain may mask other more significant symptoms. Pain should not be treated with drugs in an effort to make the patient more comfortable. The pain may be the only way to localize the problem and monitor the progress of treatment.

20-3.2.2 **Cutaneous (Skin) Symptoms.** The most common skin manifestation of decompression sickness is itching. Itching by itself is generally transient and does not require recompression. Faint skin rashes may be present in conjunction with itching. These rashes also are transient and do not require recompression. Mottling or marbling of the skin, known as cutis marmorata (marbling), may precede a symptom of serious decompression sickness and shall be treated by recompression as Type II decompression sickness. This condition starts as intense itching, progresses to redness, and then gives way to a patchy, dark-bluish discoloration of the skin. The skin may feel thickened. In some cases the rash may be raised.

20-3.2.3 **Lymphatic Symptoms.** Lymphatic obstruction may occur, creating localized pain in involved lymph nodes and swelling of the tissues drained by these nodes. Recompression may provide prompt relief from pain. The swelling, however, may take longer to resolve completely and may still be present at the completion of treatment.

20-3.3 Treatment of Type I Decompression Sickness. Type I Decompression Sickness is treated in accordance with Figure 20-2. If a full neurological exam is not completed before initial recompression, treat as a Type II symptom.

Symptoms of musculoskeletal pain that have shown absolutely no change after the second oxygen breathing period at 60 feet may be due to orthopedic injury rather than decompression sickness. If, after reviewing the patient's history, the Diving Medical Officer feels that the pain can be related to specific orthopedic trauma or injury, a Treatment Table 5 may be completed. If a Diving Medical Officer is not consulted, Treatment Table 6 shall be used.

20-3.4 Symptoms of Type II Decompression Sickness. In the early stages, symptoms of Type II decompression sickness may not be obvious and the stricken diver may consider them inconsequential. The diver may feel fatigued or weak and attribute the condition to overexertion. Even as weakness becomes more severe the diver may not seek treatment until walking, hearing, or urinating becomes difficult. Initial denial of DCS is common. For this reason, symptoms must be anticipated during the postdive period and treated before they become too severe. Type II, or serious, symptoms are divided into three categories: neurological, inner ear (staggers), and cardiopulmonary (chokes). Type I symptoms may or may not be present at the same time.

20-3.4.1 **Neurological Symptoms.** These symptoms may be the result of involvement of any level of the nervous system. Numbness, paresthesias (a tingling, pricking, creeping, “pins and needles,” or “electric” sensation on the skin), decreased sensation to touch, muscle weakness, paralysis, mental status changes, or motor performance alterations are the most common symptoms. Disturbances of higher brain function may result in personality changes, amnesia, bizarre behavior, lightheadedness, lack of coordination, and tremors. Lower spinal cord involvement can cause disruption of urinary function. Some of these signs may be subtle and can be overlooked or dismissed by the stricken diver as being of no consequence.

The occurrence of any neurological symptom after a dive is abnormal and should be considered a symptom of Type II decompression sickness or arterial gas embolism, unless another specific cause can be found. Normal fatigue is not uncommon after long dives and, by itself, is not usually treated as decompression sickness. If the fatigue is unusually severe, a complete neurological examination is indicated to ensure there is no other neurological involvement.

20-3.4.2 **Inner Ear Symptoms ("Staggers").** The symptoms of inner ear decompression sickness include: tinnitus (ringing in the ears), hearing loss, vertigo, dizziness, nausea, and vomiting. Inner ear decompression sickness has occurred most often in helium-oxygen diving and during decompression when the diver switched from breathing helium-oxygen to air. Inner ear decompression sickness should be differentiated from inner ear barotrauma, since the treatments are different. The "Staggers" has been used as another name for inner ear decompression sickness because of the afflicted diver's difficulty in walking due to vestibular system dysfunction. However, symptoms of imbalance may also be due to neurological decompression sickness involving the cerebellum. Typically, rapid involuntary eye movement (nystagmus) is not present in cerebellar decompression sickness.

20-3.4.3 **Cardiopulmonary Symptoms ("Chokes").** If profuse intravascular bubbling occurs, symptoms of chokes may develop due to congestion of the lung circulation. Chokes may start as chest pain aggravated by inspiration and/or as an irritating cough. Increased breathing rate is usually observed. Symptoms of increasing lung congestion may progress to complete circulatory collapse, loss of consciousness, and death if recompression is not instituted immediately. Careful examination for signs of pneumothorax should be performed on patients presenting with shortness of breath. Recompression is not indicated for pneumothorax if no other signs of DCS or AGE are present.

20-3.4.4 **Differentiating Between Type II DCS and AGE.** Many of the symptoms of Type II decompression sickness are the same as those of arterial gas embolism, although the time course is generally different. (AGE usually occurs within 10 minutes of surfacing.) Since the initial treatment of these two conditions is the same and since subsequent treatment conditions are based on the response of the patient to treatment, treatment should not be delayed unnecessarily in order to make the diagnosis.

20-3.5 Treatment of Type II Decompression Sickness. Type II Decompression Sickness is treated with initial compression to 60 fsw in accordance with Figure 20-1. If symptoms are improved within the first oxygen breathing period, then treatment is continued on a Treatment Table 6. If severe symptoms (e.g. paralysis, major weakness, memory loss) are unchanged or worsen within the first 20 minutes at 60 fsw, assess the patient during descent and compress to depth of relief (or significant improvement), not to exceed to 165 fsw. Treat on Treatment Table 6A. To limit recurrence, severe Type II symptoms warrant full extensions at 60 fsw even if symptoms resolve during the first oxygen breathing period.

20-3.6 Decompression Sickness in the Water. In rare instances, decompression sickness may develop in the water while the diver is undergoing decompression. The predominant symptom will usually be joint pain, but more serious manifestations such as numbness, weakness, hearing loss, and vertigo may also occur. Decompression sickness is most likely to appear at the shallow decompression stops just prior to surfacing. Some cases, however, have occurred during ascent to the first stop or shortly thereafter. Treatment of decompression sickness in the water will vary depending on the type of diving equipment in use. Specific guidelines are given in Chapter 1 for air dives, Chapter 14 for surface-supplied helium-oxygen dives, Chapter 17 for MK 16 MOD 0 dives, and Chapter 18 for MK 16 MOD 1 dives.

20-3.7 Symptomatic Omitted Decompression. If a diver has had an uncontrolled ascent and has any symptoms, he should be compressed immediately in a recompression chamber to 60 fsw. Conduct a rapid assessment of the patient and treat accordingly. Treatment Table 5 is not an appropriate treatment for symptomatic omitted decompression. If the diver surfaced from 50 fsw or shallower, compress to 60 fsw and begin Treatment Table 6. If the diver surfaced from a greater depth, compress to 60 fsw or the depth where the symptoms are significantly improved, not to exceed 165 fsw, and begin Treatment Table 6A. Consultation with a Diving Medical Officer should be obtained as soon as possible. For uncontrolled ascent deeper than 165 feet, the diving supervisor may elect to use Treatment Table 8 at the depth of relief, not to exceed 225 fsw.

Treatment of symptomatic divers who have surfaced unexpectedly is difficult when no recompression chamber is on the dive station. Immediate transportation to a recompression facility is indicated; if this is impossible, the guidelines in paragraph 20-4.4 may be useful.

20-3.8 Altitude Decompression Sickness. Decompression sickness may also occur with exposure to subatmospheric pressures (altitude exposure), as in an altitude chamber or sudden loss of cabin pressure in an aircraft. Aviators exposed to altitude may experience symptoms of decompression sickness similar to those experienced by divers. The only major difference is that symptoms of spinal cord involvement are less common and symptoms of brain involvement are more frequent in altitude decompression sickness than hyperbaric decompression sickness. Simple pain, however, still accounts for the majority of symptoms.

20-3.8.1 **Joint Pain Treatment.** If only joint pain was present but resolved before reaching one ata from altitude, then the individual may be treated with two hours of 100 percent oxygen breathing at the surface followed by 24 hours of observation.

20-3.8.2 **Other Symptoms and Persistent Symptoms.** For other symptoms or if joint pain symptoms are present after return to one ata, the stricken individual should be transferred to a recompression facility and treated on the appropriate treatment table, even if the symptoms resolve while in transport. Individuals should be kept on 100 percent oxygen during transfer to the recompression facility.

20-4 RECOMPRESSION TREATMENT FOR DIVING DISORDERS

20-4.1 Primary Objectives. Table 20-1 gives the basic rules that shall be followed for all recompression treatments. The primary objectives of recompression treatment are:

- Compress gas bubbles to a small volume, thus relieving local pressure and restarting blood flow,
- Allow sufficient time for bubble resorption, and
- Increase blood oxygen content and thus oxygen delivery to injured tissues.

20-4.2 Guidance on Recompression Treatment. Certain facets of recompression treatment have been mentioned previously, but are so important that they cannot be stressed too strongly:

- Treat promptly and adequately.
- The effectiveness of treatment decreases as the length of time between the onset of symptoms and the treatment increases.
- Do not ignore seemingly minor symptoms. They can quickly become major symptoms.
- Follow the selected treatment table unless changes are recommended by a Diving Medical Officer.
- If multiple symptoms occur, treat for the most serious condition.

20-4.3 Recompression Treatment When Chamber Is Available. Oxygen treatment tables are significantly more effective than air treatment tables. Air treatment tables shall only be used after oxygen system failure or intolerable patient oxygen toxicity problems with DMO recommendation. Treatment Table 4 can be used with or without oxygen but should always be used with oxygen if it is available.

Table 20-1. *Rules for Recompression Treatment.*

ALWAYS:

1. Follow the treatment tables accurately, unless modified by a Diving Medical Officer with concurrence of the Commanding Officer.
2. Have a qualified tender in chamber at all times during treatment.
3. Maintain the normal descent and ascent rates as much as possible.
4. Examine the patient thoroughly at depth of relief or treatment depth.
5. Treat an unconscious patient for arterial gas embolism or serious decompression sickness unless the possibility of such a condition can be ruled out without question.
6. Use air treatment tables only if oxygen is unavailable.
7. Be alert for warning signs of oxygen toxicity if oxygen is used.
8. 8n the event of an oxygen convulsion, remove the oxygen mask and keep the patient from self9harm. Do not force the mouth open during a convulsion.
9. Maintain oxygen usage within the time and depth limitations prescribed by the treatment table.
10. Check the patient's condition and vital signs periodically. Check frequently if the patient's condition is changing rapidly or the vital signs are unstable.
11. Observe patient after treatment for recurrence of symptoms. Observe 2 hours for pain9only symptoms, 6 hours for serious symptoms. Do not release patient without consulting a DMO.
12. Maintain accurate timekeeping and recording.
13. Maintain a well-stocked Primary and Secondary Emergency Kit.

NEVER:

1. Permit any shortening or other alteration of the tables, except under the direction of a Diving Medical Officer.
2. Wait for a bag resuscitator. Use mouth9to9mouth resuscitation with a barrier device immediately if breathing ceases.
3. 8nterrupt chest compressions for longer than 10 seconds.
4. Permit the use of 100 percent oxygen below 60 feet in cases of DCS or AGE.
5. Fail to treat doubtful cases.
6. Bllow personnel in the chamber to assume a cramped position that might interfere with complete blood circulation.

20-4.3.1 **Recompression Treatment With Oxygen.** Use Oxygen Treatment Table 5, 6, 6A, 4, or 7, according to the flowcharts in Figure 20-1, Figure 20-2 and Figure 20-3. The descent rate for all these tables is 20 feet per minute. Upon reaching a treatment depth of 60 fsw or shallower place the patient on oxygen. For treatment depths deeper than 60 fsw, use treatment gas if available.

20-4.3.2 **Recompression Treatments When Oxygen Is Not Available.** Air Treatment Tables 1A, 2A, and 3 (Figures 20-11, 20-12, and 20-13) are provided for use only as a last resort when oxygen is not available. Use Air Treatment Table 1A if pain is relieved at a depth less than 66 feet. If pain is relieved at a depth greater than 66 feet, use Treatment Table 2A. Treatment Table 3 is used for treatment of serious symptoms where oxygen cannot be used. Use Treatment Table 3 if symptoms are relieved within 30 minutes at 165 feet. If symptoms are not relieved in less than 30 minutes at 165 feet, use Treatment Table 4.

20-4.4 Recompression Treatment When No Recompression Chamber is Available. The Diving Supervisor has two alternatives for recompression treatment when the diving facility is not equipped with a recompression chamber. If recompression of the patient is not immediately necessary, the diver may be transported to the nearest appropriate recompression chamber or the Diving Supervisor may elect to complete in-water recompression.

20-4.4.1 **Transporting the Patient.** In certain instances, some delay may be unavoidable while the patient is transported to a recompression chamber. While moving the patient to a recompression chamber, the patient should be kept supine (lying horizontally). Do not put the patient head-down. Additionally, the patient should be kept warm and monitored continuously for signs of obstructed (blocked) airway, cessation of breathing, cardiac arrest, or shock. Always keep in mind that a number of conditions may exist at the same time. For example, the victim may be suffering from both decompression sickness and hypothermia.

20-4.4.1.1 **Medical Treatment During Transport.** Always have the patient breathe 100 percent oxygen during transport, if available. If symptoms of decompression sickness or arterial gas embolism are relieved or improve after breathing 100 percent oxygen, the patient should still be recompressed as if the original symptom(s) were still present. Always ensure the patient is adequately hydrated. Give fluids by mouth if the patient is alert and able to tolerate them. Otherwise, an IV should be inserted and intravenous fluids should be started before transport. If the patient must be transported, initial arrangements should have been made well in advance of the actual diving operations. These arrangements, which would include an alert notification to the recompression chamber and determination of the most effective means of transportation, should be posted on the Job Site Emergency Assistant Checklist for instant referral.

20-4.4.1.2 **Transport by Unpressurized Aircraft.** If the patient is moved by helicopter or other unpressurized aircraft, the aircraft should be flown as low as safely possible, preferably less than 1,000 feet. Exposure to altitude results in an additional reduction in external pressure and possible additional symptom severity or other complications. If available, always use aircraft that can be pressurized to one atmosphere. If available, transport using the Emergency Evacuation Hyperbaric Stretcher should be considered.

20-4.4.1.3 **Communications with Chamber.** Call ahead to ensure that the chamber will be ready and that qualified medical personnel will be standing by. If two-way communications can be established, consult with the doctor as the patient is being transported.

20-4.4.2 **In-Water Recompression.** Recompression in the water should be considered an option of last resort, to be used only when no recompression facility is on site, symptoms are significant and there is no prospect of reaching a recompression facility within a reasonable timeframe (12K24 hours). In an emergency, an uncertified chamber may be used if, in the opinion of a qualified Chamber Supervisor (DSWS Watchstation 305), it is safe to operate. In divers with severe Type II symptoms, or symptoms of arterial gas embolism (e.g., unconsciousness, paralysis, vertigo, respiratory distress (chokes), shock, etc.), the risk of increased harm to the diver from in-water recompression probably outweighs any anticipated benefit. Generally, these individuals should not be recompressed in the water, but should be kept at the surface on 100 percent oxygen, if available, and evacuated to a recompression facility regardless of the delay. The stricken diver should begin breathing 100 percent oxygen immediately (if it is available). Continue breathing oxygen at the surface for 30 minutes before committing to recompress in the water. If symptoms stabilize, improve, or relief on 100 percent oxygen is noted, do not attempt in-water recompression unless symptoms reappear with their original intensity or worsen when oxygen is discontinued. Continue breathing 100 percent oxygen as long as supplies last, up to a maximum time of 12 hours. The patient may be given air breaks as necessary. If surface oxygen proves ineffective after 30 minutes, begin in-water recompression. To avoid hypothermia, it is important to consider water temperature when performing in-water recompression.

20-4.4.2.1 **In-Water Recompression Using Air.** In-water recompression using air is always less preferable than in-water recompression using oxygen.

- Follow Air Treatment Table 1A as closely as possible.
- Use either a full face mask or, preferably, a surface-supplied helmet UBA.
- Never recompress a diver in the water using a SCUBA with a mouth piece unless it is the only breathing source available.
- Maintain constant communication.
- Keep at least one diver with the patient at all times.
- Plan carefully for shifting UBAs or cylinders.
- Have an ample number of tenders topside.
- If the depth is too shallow for full treatment according to Air Treatment Table 1A:
- Recompress the patient to the maximum available depth.
- Remain at maximum depth for 30 minutes.
- Decompress according to Air Treatment Table 1A. Do not use stops shorter than those of Air Treatment Table 1A.

20-4.4.2.2 **In-Water Recompression Using Oxygen.** If 100 percent oxygen is available to the diver using an oxygen rebreather, an ORCA, or other device, the following in- water recompression procedure should be used instead of Air Treatment Table 1A:

- Put the stricken diver on the UBA and have the diver purge the apparatus at least three times with oxygen.
- Descend to a depth of 30 feet with a standby diver.
- Remain at 30 feet, at rest, for 60 minutes for Type I symptoms and 10 minutes for Type II symptoms. Ascend to 20 feet even if symptoms are still present.
- Decompress to the surface by taking 60-minute stops at 20 feet and 10 feet.
- After surfacing, continue breathing 100 percent oxygen for an additional 3 hours.
- If symptoms persist or recur on the surface, arrange for transport to a recompression facility regardless of the delay.

20-4.4.2.3 **Symptoms After In-Water Recompression.** The occurrence of Type II symptoms after in-water recompression is an ominous sign and could progress to severe, debilitating decompression sickness. It should be considered life-threatening. Operational considerations and remoteness of the dive site will dictate the speed with which the diver can be evacuated to a recompression facility.

2.5 TREATMENT TABLES

20-5.1 Air Treatment Tables. Air Treatment Tables 1A, 2A, and 3 (Figures 20-11, 20-12, and 20-13) are provided for use only as a last resort when oxygen is not available. Oxygen treatment tables are significantly more effective than air treatment tables and shall be used whenever possible.

20-5.2 Treatment Table 5. Treatment Table 5, Figure 20-4, may be used for the following:

- Type I DCS (except for cutis marmorata) symptoms when a complete neurological examination has revealed no abnormality. After arrival at 60 fsw a neurological exam shall be performed to ensure that no overt neuro- logical symptoms (e.g., weakness, numbness, loss of coordination) are present. If any abnormalities are found, the stricken diver should be treated using Treatment Table 6.
- Asymptomatic omitted decompression
- Treatment of resolved symptoms following in-water recompression
- Follow-up treatments for residual symptoms
- Carbon monoxide poisoning
- Gas gangrene

20-5.3 Treatment Table 6. Treatment Table 6, Figure 20-5, is used for the following:

- Arterial gas embolism
- Type II DCS symptoms
- Type I DCS symptoms where relief is not complete within 10 minutes at 60 feet or where pain is severe and immediate recompression must be instituted before a neurological examination can be performed
- Cutis marmorata
- Severe carbon monoxide poisoning, cyanide poisoning, or smoke inhalation
- Asymptomatic omitted decompression

- Symptomatic uncontrolled ascent
- Recurrence of symptoms shallower than 60 fsw

20-5.4 **Treatment Table 6A.** Treatment Table 6A, Figure 20-6, is used to treat arterial gas embolism or decompression symptoms when severe symptoms remain unchanged or worsen within the first 20 minutes at 60 fsw. The patient is compressed to depth of relief (or significant improvement), not to exceed 165 fsw. Once at the depth of relief, begin treatment gas (N_2O_2, HeO_2) if available. Consult with a Diving Medical Officer at the earliest opportunity. If the severity of the patient's condition warrants, the Diving Medical Officer may recommend conversion to a Treatment Table 4.

NOTE **If deterioration or recurrence of symptoms is noted during ascent to 60 feet, treat as a recurrence of symptoms (Figure 20-3).**

20-5.5 **Treatment Table 4.** Treatment Table 4, Figure 20-7, is used when it is determined that the patient would receive additional benefit at depth of significant relief, not to exceed 165 fsw. The time at depth shall be between 30 to 120 minutes, based on the patient's response. If a shift from Treatment Table 6A to Treatment Table 4 is contemplated, a Diving Medical Officer should be consulted before the shift is made.

If oxygen is available, the patient should begin oxygen breathing periods immediately upon arrival at the 60-foot stop. Breathing periods of 25 minutes on oxygen, interrupted by 5 minutes of air, are recommended because each cycle lasts 30 minutes. This simplifies timekeeping. Immediately upon arrival at 60 feet, a minimum of four oxygen breathing periods (for a total time of 2 hours) should be administered. After that, oxygen breathing should be administered to suit the patient's individual needs and operational conditions. Both the patient and tender must breathe oxygen for at least 4 hours (eight 25-minute oxygen, 5-minute air periods), beginning no later than 2 hours before ascent from 30 feet is begun. These oxygen-breathing periods may be divided up as convenient, but at least 2 hours' worth of oxygen breathing periods should be completed at 30 feet.

NOTE **If deterioration or recurrence of symptoms is noted during ascent to 60 feet, treat as a recurrence of symptoms (Figure 20-3).**

20-5.6 **Treatment Table 7.** Treatment Table 7, Figure 20-8, is an extension at 60 feet of Treatment Table 6, 6A, or 4 (or any other nonstandard treatment table). This means that considerable treatment has already been administered. Treatment Table 7 is considered a heroic measure for treating non-responding severe gas embolism or life-threatening decompression sickness and is not designed to treat all residual symptoms that do not improve at 60 feet and should never be used to treat residual pain. Treatment Table 7 should be used only when loss of life may result if the currently prescribed decompression from 60 feet is undertaken. Committing a patient to a Treatment Table 7 involves isolating the patient and having to minister to his medical needs in the recompression chamber for 48 hours or longer. Experienced diving medical personnel shall be on scene.

A Diving Medical Officer should be consulted before shifting to a Treatment Table 7 and careful consideration shall be given to life support capability of the recompression facility. Because it is difficult to judge whether a particular patient's condition warrants Treatment Table 7, additional consultation may be obtained from either NEDU or NDSTC.
When using Treatment Table 7, a minimum of 12 hours should be spent at 60 feet, including time spent at 60 feet from Treatment Table 4, 6, or 6A. Severe Type II decompression sickness and/or arterial gas embolism cases may continue to deteriorate significantly over the first several hours. This should not be cause for premature changes in depth. Do not begin decompression from 60 feet for at least 12 hours. At completion of the 12-hour stay, the decision must be made whether to decompress or spend additional time at 60 feet. If no improvement was noted during the first 12 hours, benefit from additional time at 60 feet is unlikely and decompression should be started. If the patient is improving but significant residual symptoms remain (e.g., limb paralysis, abnormal or absent respiration), additional time at 60 feet may be warranted. While the actual time that can be spent at 60 feet is unlimited, the actual additional amount of time beyond 12 hours that should be spent can only be determined by a Diving Medical Officer (in consultation with on-site supervisory personnel), based on the patient's response to therapy and operational factors. When the patient has progressed to the point of consciousness, can breathe independently, and can move all extremities, decompression can be started and maintained as long as improvement continues. Solid evidence of continued benefit should be established for stays longer than 18 hours at 60 feet. Regardless of the duration at the recompression deeper than 60 feet, at least 12 hours must be spent at 60 feet and then Treatment Table 7 followed to the surface. Additional recompression below 60 feet in these cases should not be undertaken unless adequate life support capability is available.

20-5.6.1 **Decompression.** Decompression on Treatment Table 7 is begun with an upward excursion at time zero from 60 to 58 feet. Subsequent 2-foot upward excursions are made at time intervals listed as appropriate to the rate of decompression:

Table 20-2. *Decompression*

Depth	Ascent Rate	Time Interval
58-40 feet	3 ft/hr	40 min
40-20 feet	2 ft/hr	60 min
20-4 feet	1 ft/hr	120 min

The travel time between stops is considered as part of the time interval for the next shallower stop. The time intervals shown above begin when ascent to the next shallower stop has begun.

20-5.6.2 **Tenders.** When using Treatment Table 7, tenders breathe chamber atmosphere throughout treatment and decompression.

20-5.6.3 **Preventing Inadvertent Early Surfacing.** Upon arrival at 4 feet, decompression should be stopped for 4 hours. At the end of 4 hours, decompress to the surface at 1 foot per minute. This procedure prevents inadvertent early surfacing.

20-5.6.4 **Oxygen Breathing.** On a Treatment Table 7, patients should begin oxygen breathing periods as soon as possible at 60 feet. Oxygen breathing periods of 25 minutes on 100 percent oxygen, followed by 5 minutes breathing chamber atmosphere, should be used. Normally, four oxygen breathing periods are alternated with 2 hours of continuous air breathing. In conscious patients, this cycle should be continued until a minimum of eight oxygen breathing periods have been administered (previous 100 percent oxygen breathing periods may be counted against these eight periods). Beyond that, oxygen breathing periods should be continued as recommended by the Diving Medical Officer, as long as improvement is noted and the oxygen is tolerated by the patient. If oxygen breathing causes significant pain on inspiration, it should be discontinued unless it is felt that significant benefit from oxygen breathing is being obtained. In unconscious patients, oxygen breathing should be stopped after a maximum of 24 oxygen breathing periods have been administered. The actual number and length of oxygen breathing periods should be adjusted by the Diving Medical Officer to suit the individual patient's clinical condition and response to pulmonary oxygen toxicity.

20-5.6.5 **Sleeping, Resting, and Eating.** At least two tenders should be available when using Treatment Table 7, and three may be necessary for severely ill patients. Not all tenders are required to be in the chamber, and they may be locked in and out as required following appropriate decompression tables. The patient may sleep anytime except when breathing oxygen deeper than 30 feet. While asleep, the patient's pulse, respiration, and blood pressure should be monitored and recorded at intervals appropriate to the patient's condition. Food may be taken at any time and fluid intake should be maintained.

20-5.6.6 **Ancillary Care.** 0atients on Treatment Table 7 requiring intravenous and/or drug therapy should have these administered in accordance with paragraph 20-11 and associated subparagraphs.

20-5.6.7 **Life Support.** Before committing to a Treatment Table 7, the life-support consider- ations in paragraph 20-7 must be addressed. Do not commit to a Treatment Table 7 if the internal chamber temperature cannot be maintained at 85)F (21)C) or less.

20-5.7 Treatment Table 8. Treatment Table 8, Figure 20-1, is an adaptation of Royal Navy Treatment Table 65 mainly for treating deep uncontrolled ascents (see Chapter 14) when more than 60 minutes of decompression have been missed. Compress symptomatic patient to depth of relief not to exceed 225 fsw. Initiate Treatment Table 8 from depth of relief. The schedule for Treatment Table 8 from 60 fsw is the same as Treatment Table 7. The guidelines for sleeping and eating are the same as Treatment Table 7.

20-5.8 Treatment Table 9. Treatment Table 9, Figure 20-10, is a hyperbaric oxygen treatment table providing 10 minutes of oxygen breathing at 45 feet. This table is used only on the recommendation of a Diving Medical Officer cognizant of the patient's medical condition. Treatment Table 9 is used for the following:

1. Residual symptoms remaining after initial treatment of AGE/DCS
2. Selected cases of carbon monoxide or cyanide poisoning
3. Smoke inhalation

This table may also be recommended by the cognizant Diving Medical Officer when initially treating a severely injured patient whose medical condition precludes long absences from definitive medical care.

20-6 RECOMPRESSION TREATMENT FOR NON-DIVING DISORDERS

In addition to individuals suffering from diving disorders, U.S. Navy recompression chambers are also permitted to conduct emergent hyperbaric oxygen (HBO_2) therapy to treat individuals suffering from cyanide poisoning, carbon monoxide poisoning, gas gangrene, smoke inhalation, necrotizing soft-tissue infections, or arterial gas embolism arising from surgery, diagnostic procedures, or thoracic trauma. If the chamber is to be used for treatment of non-diving related medical conditions other than those listed above, authorization from BUMED Code M3B42 shall be obtained before treatment begins (BUMEDINST 6320.38 series.) Any treatment of a non-diving related medical condition shall be done under the cognizance of a Diving Medical Officer.

The guidelines given in Table 20-3 for conducting HBO_2 therapy are taken from the Undersea and Hyperbaric Medical Society's Hyperbaric Oxygen (HBO_2) Therapy Committee Report-2003: Approved Indications for Hyperbaric Oxygen Therapy. For each condition, the guidelines prescribe the recommended Treatment Table, the frequency of treatment, and the minimum and maximum number of treatments.

Table 20-3. *Guidelines for Conducting Hyperbaric Oxygen Therapy.*

Indication	Treatment Table	Minimum # Treatments	Maximum # Treatments
Carbon Monoxide Poisoning and Smoke Inhalation	Treatment Table 5 or Table 6 as recommended by the DMO	1	5
Gas Gangrene FClostridial Myonecrosis)	Treatment Table 5 T8D ▌ 1 day then 68D ▌ 495 days	5	10
Crush 8njury, Compartment Syndrome, and other Acute Traumatic Ischemia	Treatment Table 9 T8D ▌ 2 days 68D ▌ 2 days QD ▌ 2 days	3	12
Enhancements of Healing in Selected @ounds	Treatment Table 9 QD or 68D	10	60
Lecrotizing Soft9Tissue 8nfections Fsubcutaneous tissue, muscle, fascia)	Treatment Table 9 68D initially, then QD	5	30
Osteomyelitis Frefractory)	Treatment Table 9 QD	20	60
Nadiation Tissue Damage Fosteoradinecrosis)	Treatment Table 9 QD	20	60
Skin Grafts and Flaps	Treatment Table 9 68D initially, then QD	6	40
Thermal Burns	Treatment Table 9 T8D ▌ 1 day, then 68D	5	45

QD = 1 time in 24 hours 68D = 2 times in 24 hours T8D = 3 times in 24 hours
For further information, see Hyperbaric Oxygen Therapy: B Committee Neport, 2003 Nevision.

20-7 RECOMPRESSION CHAMBER LIFE-SUPPORT CONSIDERATIONS

The short treatment tables (Oxygen Treatment Tables 5, 6, 6A, 1; Air Treatment Tables 1A and 2A) can be accomplished easily without significant strain on either the recompression chamber facility or support crew. The long treatment tables (Tables 3, 4, 7, and 8) will require long periods of decompression and may tax both personnel and hardware severely.

20-7.1 Minimum Manning Requirements. The minimum team for conducting any recompression operation shall consist of three individuals. In case of emergency, the recompression chamber can be manned with two individuals.

- The Diving Supervisor is in complete charge at the scene of the operation, keeping individual and overall times on the operation, logging progress, and communicating with personnel inside the chamber.
- The Outside Tender is responsible for the operation of gas supplies, ventilation, pressurization, and exhaust of the chamber.
- The Inside Tender is familiar with the diagnosis and treatment of diving-related illnesses.

20-7.2 Optimum Manning Requirements. The optimum team for conducting recompression operations consists of four individuals:

- The Diving Supervisor is in complete charge at the scene of the operation.
- The Outside Tender 91 is responsible for the operation of the gas supplies, ventilation, pressurization, and exhaust of the chamber.
- The Outside Tender 92 is responsible for keeping individuals' and overall times on the operation, logging progress as directed by the Diving Supervisor, and communicating with personnel inside the chamber.
- The Inside Tender is familiar with the diagnosis and treatment of diving-related illnesses.

20-7.2.1 **Additional Personnel.** If the patient has symptoms of serious decompression sickness or arterial gas embolism, the team will require additional personnel. If the treatment is prolonged, a second team may have to relieve the first team. 0atients with serious decompression sickness and gas embolism would initially be accompanied inside the chamber by a Diving Medical Technician or Diving Medical Officer, if possible. However, treatment should not be delayed to comply with this recommendation.

20-7.2.2 **Required Consultation by a Diving Medical Officer.** A Diving Medical Officer shall be consulted as early as possible in all recompression treatments, and, if at all possible, before committing the patient to a Treatment Table 4, 7, or 8. The Diving Medical Officer may be on scene or in communication with the Diving Supervisor. In all cases a DMO must be consulted prior to releasing a patient from treatment.

20-7.3 Oxygen Control. All treatment schedules listed in this chapter are usually performed with a chamber atmosphere of air. To accomplish safe decompression, the oxygen percentage should not be allowed to fall below 11 percent. Oxygen may be added to the chamber by ventilating with air or by bleeding in oxygen from an oxygen breathing system. If a portable oxygen analyzer is available, it can be used to determine the adequacy of ventilation and/or addition of oxygen. If no oxygen analyzer is available, ventilation of the chamber in accordance with paragraph 20-7.6 will ensure adequate oxygenation. Chamber oxygen percentages as high as 25 percent are permitted. If the chamber is equipped with a life-support system so that ventilation is not required and an oxygen analyzer is available, the oxygen level should be maintained between 11 percent and 25 percent. If chamber oxygen goes above 25 percent, ventilation with air should be used to bring the oxygen percentage down.

20-7.4 Carbon Dioxide Control. Ventilation of the chamber in accordance with paragraph 20-7.6 will ensure that carbon dioxide produced metabolically does not cause the chamber carbon dioxide level to exceed 1.5 percent SEV (11.4 mmHg).

20-7.4.1 **Carbon Dioxide Monitoring.** Chamber carbon dioxide should be monitored with electronic carbon dioxide monitors. Monitors generally read CO_2 percentage once chamber air has been exhausted to the surface. The CO_2 percent reading at the surface 1 ata must be corrected for depth. To keep chamber CO_2 below 1.5 percent SEV (11.4 mmHg), the surface CO_2 monitor values should remain below 0.78 percent with chamber depth at 30 feet, 0.53 percent with chamber depth at 60 feet, and 0.25 percent with the chamber at 165 feet. If the CO_2 analyzer is within the chamber, no correction to the CO_2 readings is necessary.

20-7.4.2 **Carbon Dioxide Scrubbing.** If the chamber is equipped with a carbon dioxide scrubber, the absorbent should be changed when the partial pressure of carbon di- oxide in the chamber reaches 1.5 percent SEV (11.4 mmHg). If absorbent cannot be changed, supplemental chamber ventilation will be required to maintain chamber CO_2 at acceptable levels. With multiple or working chamber occupants, supplemental ventilation may be necessary to maintain chamber CO_2 at acceptable levels.

20-7.4.3 **Carbon Dioxide Absorbent.** CO_2 absorbent may be used beyond the expiration date when used in a recompression chamber equipped with a CO_2 monitor. When used in a recompression chamber that has no CO_2 monitor, CO_2 absorbent in an opened but resealed bucket may be used until the expiration date on the bucket is reached. 0re-packed, double-bagged canisters shall be labeled with the expiration date from the absorbent bucket for recompression chambers with no CO_2 monitor.

20-7.5 Temperature Control. Internal chamber temperature should be maintained at a level comfortable to the occupants whenever possible. Cooling can usually be accomplished by chamber ventilation. If the chamber is equipped with a heater/ chiller unit, temperature control can usually be maintained for chamber occupant comfort under any external environmental conditions. Usually, recompression chambers will become hot and must be cooled continuously. Chambers should always be shaded from direct sunlight. The maximum durations for chamber occupants will depend on the internal chamber temperature as listed in Table 20-4. Never commit to a treatment table that will expose the chamber occupants to greater temperature/time combinations than listed in Table 20-4 unless qualified medical personnel who can evaluate the trade-off between the projected heat stress and the anticipated treatment benefit are consulted. A chamber temperature below 85)F (21)C) is always desirable, no matter which treatment table is used.

For patients with brain or spinal cord damage, the current evidence recommends aggressive treatment of elevated body temperature. When treating victims of AGE or severe neurological DCS, hot environments that elevate body temperature above normal should be avoided, whenever possible. As in DCS, patient temperature should be a routinely monitored vital sign.

Table 20-4. *Maximum Permissible Recompression Chamber Exposure Times at Various Temperatures.*

Internal Temperature	Maximum Tolerance Time	Permissible Treatment Tables
Over 104SF F40SC)	Intolerable	No treatments
95-104SF F34.4-40SC)	2 hours	Table 5, 9
85-94SF F29-34.4SC)	6 hours	Tables 5, 6, 6A, 1A, 9
Under 85SF F29SC)	Unlimited	All treatments

NOTE:
Internal chamber temperature can be kept considerably below ambient by venting or by using an installed chiller unit. 8nternal chamber temperature can be measured using electronic, bimetallic, alcohol, or liquid crystal thermometers. Lever use a mercury thermometer in or around hyperbaric chambers. Since chamber ventilation will produce temperature swings during ventilation, the above limits should be used as averages when controlling temperature by ventilation. Always shade chamber from direct sunlight.

20-7.5.1 **Patient Hydration.** Always ensure patients are adequately hydrated. Fully conscious patients may be given fluid by mouth to maintain adequate hydration. One to two liters of water, juice, or non-carbonated drink, over the course of a Treatment Table 5 or 6, is usually sufficient. 0atients with Type II symptoms, or symptoms of arterial gas embolism, should be considered for IV fluids. Stuporous or unconscious patients should always be given IV fluids, using large-gauge plastic catheters. If trained personnel are present, an IV should be started as soon as possible and kept dripping at a rate of 75 to 100 cc/hour, using isotonic fluids (Lactated Ringer's Solution, Normal Saline) until specific instructions regarding the rate and type of fluid administration are given by qualified medical personnel. Avoid solutions containing glucose (Dextrose) if brain or spinal cord injury is present. Intravenously administered glucose may worsen the outcome. In some cases, the bladder may be paralyzed. The victim's ability to void shall be assessed as soon as possible. If the patient cannot empty a full bladder, a urinary catheter shall be inserted as soon as possible by trained personnel. Always inflate catheter balloons with liquid, not air. Adequate fluid is being given when urine output is at least 0.5cc/kg/hr. Thirst is an unreliable indicator of the water intake to compensate for heavy sweating. A useful indicator of proper hydration is a clear colorless urine.

20-7.6 Chamber Ventilation. Ventilation is the usual means of controlling oxygen level, carbon dioxide level, and temperature. Ventilation using air is required for chambers without carbon dioxide scrubbers and atmospheric analysis. A ventilation rate of two acfm for each resting occupant, and four acfm for each active occupant, should be used. These procedures are designed to assure that the effective concentration of carbon dioxide will not exceed 1.5 percent sev (11.4 mmHg) and that, when oxygen is being used, the percentage of oxygen in the chamber will not exceed 25 percent.

20-7.7 Access to Chamber Occupants. Recompression treatments usually require access to occupants for passing in items such as food, water, and drugs and passing out such items as urine, excrement, and trash. Never attempt a treatment longer than a Treatment Table 6 unless there is access to inside occupants. When doing a Treatment Table 4, 7, or 8, a double-lock chamber is mandatory because additional personnel may have to be locked in and out during treatment.

20-7.8 Inside Tenders. When conducting a recompression treatment, at least one qualified tender shall be inside the chamber. The inside tender shall be familiar with all treatment procedures and the signs, symptoms, and treatment of all diving-related disorders. Medical personnel may have to be locked into the chamber as the patient's condition dictates.

20-7.8.1 **Inside Tender Responsibilities.** During the early phases of treatment, the inside tender must monitor the patient constantly for signs of relief. Drugs that mask signs of the illness should not be given. Observation of these signs is the principal method of diagnosing the patient's illness. Furthermore, the depth and time of their relief helps determine the treatment table to be used. The inside tender is also responsible for:

- Releasing the door latches (dogs) after a seal is made
- Communicating with outside personnel
- Providing first aid as required by the patient
- Administering treatment gas to the patient at treatment depth
- Providing normal assistance to the patient as required
- Ensuring that sound attenuators for ear protection are worn during compression and ventilation portions of recompression treatments.
- Ensuring that the patient is lying down and positioned to permit free blood circulation to all extremities.

20-7.8.2 **DMO or DMT Inside Tender.** If it is known before the treatment begins that adjunctive therapy or advanced medical support must be administered to the patient (examples include an IV, or airway maintenance), or if the patient is suspected of suffering from arterial gas embolism, a Diving Medical Technician or Diving Medical Officer should accompany the patient inside the chamber. However, recompression treatment must not be delayed while awaiting the arrival of the DMO or DMT.

20-7.8.3 **Use of Diving Medical Officer as Inside Tender.** If only one Diving Medical Officer is on site, the Medical Officer should lock in and out as the patient's condition dictates, but should not commit to the entire treatment unless absolutely necessary. Once committed to remain in the chamber, the Diving Medical Officer effectiveness in directing the treatment is greatly diminished and consultation with other medical personnel becomes more difficult. If periods in the chamber are necessary, visits should be kept within no-decompression limits if possible.

20-7.8.4 **Non-Diver Inside Tender - Medical.** Non-diving medical personnel may be qualified as Inside Tenders (examples would include U.S. Naval Reserve Corpsmen, and nursing personnel). Qualifications may be achieved through Navy Diver Inside Tender 0FS. 0rerequisites: Current diving physical exam, conformance to Navy physical standards, and diver candidate pressure test.

20-7.8.5 **Specialized Medical Care.** Emergency situations that require specialized medical care should always have the best qualified person provide it. The best qualified person may be a surgeon, respiratory therapist, IDC, etc. Since these are emergency exposures, no special medical or physical prerequisites exist. A qualified Inside Tender is required inside the chamber to handle any system related requirements.

20-7.8.6 **Inside Tender Oxygen Breathing.** During treatments, all chamber occupants may breathe 100 percent oxygen at depths of 45 feet or shallower without locking in additional personnel. Tenders should not fasten the oxygen masks to their heads, but should hold them on their faces. When deeper than 45 feet, at least one chamber occupant must breathe air. Tender oxygen breathing requirements are specified in the figure for each Treatment Table.

20-7.8.7 **Tending Frequency.** Normally, tenders should allow a surface interval of at least 18 hours between consecutive treatments on Treatment Tables 1A, 2A, 3, 5, 6, and 6A, and at least 48 hours between consecutive treatments on Tables 4, 7, and 8. If necessary, however, tenders may repeat Treatment Tables 5, 6, or 6A within this 18-hour surface interval if oxygen is breathed at 30 feet and shallower as outlined in Table 20-6. Minimum surface intervals for Treatment Tables 1A, 2A, 3, 4, 7, and 8 shall be strictly observed.

20-7.9 Equalizing During Descent. Descent rates may have to be decreased as necessary to allow the patient to equalize; however, it is vital to attain treatment depth in a timely manner for a suspected arterial gas embolism patient.

20-7.10 Use of High Oxygen Mixes. High oxygen N_2O_2/HeO_2 mixtures may be used to treat patients when recompression deeper than 60 fsw is required. These mixtures offer significant therapeutic advantages over air. Select a treatment gas that will produce a ppO_2 between 1.5 and 3.0 ata at the treatment depth. The standardized gas mixtures shown in Table 20-4 are suitable over the depth range of 61-225 fsw.

Decompression sickness following helium dives can be treated with either nitrogen or helium mixtures. For recompression deeper than 165 fsw, helium mixtures are preferred to avoid narcosis. The situation is less clear for treatment of decompression sickness following air or nitrogen-oxygen dives. Experimental studies have shown both benefit and harm with helium treatment. Until more experience is obtained, high oxygen mixtures with nitrogen as the diluent gas are preferred if available. High oxygen mixtures may also be substituted for 100% oxygen at 60 fsw and shallower on Treatment Tables 4, 7, and 8 if the patient is unable to tolerate 100% oxygen.

Table 20-5. *High Oxygen Treatment Gas Mixtures.*

Depth (fsw)	Mix (HeO_2 or N_2O_2)	ppO_2
0-60	100%	1.00-2.82
61-165	50/50	1.42-3.00
166-225	64/36 FHeO_2 only)	2.17-2.81

20-7.11 Oxygen Toxicity During Treatment. Acute CNS oxygen toxicity may develop on any oxygen treatment table.

During prolonged treatments on Treatment Tables 4, 7, or 8, and with repeated Treatment Table 6, pulmonary oxygen toxicity may also develop.

20-7.11.1 **Central Nervous System Oxygen Toxicity.** When employing the oxygen treatment tables, tenders must be particularly alert for the early symptoms of CNS oxygen toxicity. The symptoms can be remembered readily by using the mnemonic VENTID-C (Vision, Ears, Nausea, Twitching/Tingling, Irritability, Dizziness, Convulsions). Unfortunately, a convulsion may occur without early warning signs or before the patient can be taken off oxygen in response to the first sign of CNS oxygen toxicity. CNS oxygen toxicity is unlikely in resting individuals at chamber depths of 50 feet or shallower and very unlikely at 30 feet or shallower, regardless of the level of activity. However, patients with severe Type II decompression sickness or arterial gas embolism symptoms may be abnormally sensitive to CNS oxygen toxicity. Convulsions unrelated to oxygen toxicity may also occur and may be impossible to distinguish from oxygen seizures.

20-7.11.1.1 **Procedures in the Event of CNS Oxygen Toxicity.** At the first sign of CNS oxygen toxicity, the patient should be removed from oxygen and allowed to breathe chamber air. Fifteen minutes after all symptoms have subsided, resume oxygen breathing. For Treatment Tables 5, 6, 6A resume treatment at the point of interruption. For Treatment Tables 4, 7 and 8 no compensatory lengthening of the table is required. If symptoms of CNS oxygen toxicity develop again or if the first symptom is a convulsion, take the follow action:

CAUTION Inserting an airway device or bite block is not recommended while the patient is convulsing; it is not only difficult, but may cause harm if attempted.

For Treatment Tables 5, 6, and 6A:

- Remove the mask
- After all symptoms have completely subsided, decompress 10 feet at a rate of 1 fsw/min. For a convulsion, begin travel when the patient is fully relaxed and breathing normally.
- Resume oxygen breathing at the shallower depth at the point of interruption.
- If another oxygen symptom occurs after ascending 10 fsw, contact a Diving Medical Officer to recommend appropriate modifications to the treatment schedule.

For Treatment Tables 4, 7, and 8:

- Remove the mask.
- Consult with a Diving Medical Officer before administering further oxygen breathing. No compensatory lengthening of the table is required for interruption in oxygen breathing

20-7.11.2 **Pulmonary Oxygen Toxicity.** 0ulmonary oxygen toxicity is unlikely to develop on single Treatment Tables 5, 6, or 6A. On Treatment Tables 4, 7, or 8 or with repeated Treatment Tables 5, 6, or 6A (especially with extensions) prolonged exposure to oxygen may result in end-inspiratory discomfort, progressing to substernal burning and severe pain on inspiration. If a patient who is responding well to treatment complains of substernal burning, discontinue use of oxygen and consult with a DMO. However, if a significant neurological deficit remains and improvement is continuing (or if deterioration occurs when oxygen breathing is interrupted), oxygen breathing should be continued as long as considered beneficial or until pain limits inspiration. If oxygen breathing must be continued beyond the period of substernal burning, or if the 2-hour air breaks on Treatment Tables 4, 7, or 8 cannot be used because of deterioration upon the discontinuance of oxygen, the oxygen breathing periods should be changed to 20 minutes on oxygen, followed by 10 minutes breathing chamber air or alternative treatment gas mixtures with a lower percentage of oxygen should be considered. The Diving Medical Officer may tailor the above guidelines to suit individual patient response to treatment.

20-7.12 Loss of Oxygen During Treatment. Loss of oxygen breathing capability during oxygen treatments is a rare occurrence. However, should it occur, the following actions should be taken:

If repair can be completed within 15 minutes:
- Maintain depth until repair is completed.
- After O_2 is restored, resume treatment at point of interruption.
- If repair can be completed after 15 minutes but before 2 hours:
- Maintain depth until repair is completed.
- After O_2 is restored: If original table was Table 5, 6, or 6A, complete treatment with maximum number of O_2 extensions.

20-7.12.1 **Compensation.** If Table 4, 7, or 8 is being used, no compensation in decompression is needed if oxygen is lost. If decompression must be stopped because of worsening symptoms in the affected diver, then stop decompression. When oxygen is restored, continue treatment from where it was stopped.

20-7.12.2 **Switching to Air Treatment Table.** If O_2 breathing cannot be restored in 2 hours, switch to the comparable air treatment table at current depth for decompression if 60 fsw or shallower. Rate of ascent must not exceed 1 fpm between stops. If symptoms worsen and an increase in treatment depth deeper than 60 feet is needed, use Treatment Table 4.

20-7.13 Treatment at Altitude. Before starting recompression therapy, zero the chamber depth gauges to adjust for altitude. Then use the depths as specified in the treatment table. There is no need to "Cross Correct" the treatment table depths. Divers serving as inside tenders during hyperbaric treatments at altitude are performing a dive at altitude and therefore require more decompression than at sea level. Tenders locking into the chamber for brief periods should be managed according to the Diving At Altitude procedures (Chapter 1, paragraph 1-13). Tenders remaining in the chamber for the full treatment table must breathe oxygen during the terminal portion of the treatment to satisfy their decompression requirement.

The additional oxygen breathing required at altitude on Treatment Table 5, Treat- ment Table 6, and Treatment Table 6A is given in Table 20-6. The requirement pertains both to tenders equilibrated at altitude and to tenders flown directly from sea level to the chamber location. Contact NEDU for guidance on tender oxygen requirements for other treatment tables.

20-8 POST-TREATMENT CONSIDERATIONS

Tenders on Treatment Tables 5, 6, 6A, 1A, 2A, or 3 should have a minimum of a 18-hour surface interval before no-decompression diving and a minimum of a 24-hour surface interval before dives requiring decompression stops. Tenders on Treatment Tables 4, 7, and 8 should have a minimum of a 48-hour surface interval prior to diving.

20-8.1 Post-Treatment Observation Period. After a treatment, patients treated on a Treat- ment Table 5 should remain at the recompression chamber facility for 2 hours. 0a- tients who have been treated for Type II decompression sickness or who required a Treatment Table 6 for Type I symptoms and have had complete relief should re- main at the recompression chamber facility for 6 hours. 0atients treated on Treat- ment Tables 6, 6A, 4, 7, 8 or 9 are likely to require a period of hospitalization, and the Diving Medical Officer will need to determine a post-treatment observa- tion period and location appropriate to their response to recompression treatment. These times may be shortened upon the recommendation of a Diving Medical Of- ficer, provided the patient will be with personnel who are experienced at recognizing recurrence of symptoms and can return to the recompression facility within 30 minutes. All patients should remain within 60 minutes travel time of a recompres- sion facility for 24 hours and should be accompanied throughout that period. No patient shall be released until authorized by a DMO.

Treatment table profiles place the inside tender(s) at risk for decompression sick- ness. After completing treatments, inside tenders should remain in the vicinity of the recompression chamber for 1 hour. If they were tending for Treatment Table 4, 7, or 8, inside tenders should also remain within 60 minutes travel time of a recompression facility for 24 hours.

Table 20-6. *Tender Oxygen Breathing Requirements. (Note 1)*

		Altitude		
Treatment Table FTT)		Surface to 2499 ft	2500 ft. - 7499 ft.	7500 ft. - 10,000 ft.
TT5 Note (2)	without extension	:00	:00	:00
	with extension @ 30 fsw	:00	:00	:20
TT6 Note (2)	up to one extension @ 60 fsw or 30 fsw	:30	:60	:90
	more than one extension	:60	:90	:120
TT6A Note (2)	up to one extension @ 60 fsw or 30 fsw	:60	:120	:150 Note (3)
	more than one extension	:90	:150 Note	:180 Note

Note 1: All tender O_2 breathing times in table are conducted at 30 fsw. In addition, tenders will breathe O_2 on ascent from 30 fsw to the surface.

Note 2: If the tender had a previous hyperbaric exposure within 18 hours, use the following guidance for administering O_2:
For TT5, add an additional 20 minute O_2 breathing period to the times in the table.
For TT6 or TT6A, add an additional 60 minute O_2 breathing period to the times in the table.
For other Treatment tables contact NEDU for guidance.

Note 3: In some instances, tender's oxygen breathing obligation exceeds the table stay time at 30 fsw. Extend the time at 30 fsw to meet these obligations if patient's condition permits. Otherwise, administer O_2 to the tender to the limit allowed by the treatment table and observe the tender on the surface for 1 hour for symptoms of DCS.

20-8.2 Post-Treatment Transfer. 0atients with residual symptoms should be transferred to appropriate medical facilities as directed by qualified medical personnel. If ambulatory patients are sent home, they should always be accompanied by someone familiar with their condition who can return them to the recompression facility should the need arise. 0atients completing treatment do not have to remain in the vicinity of the chamber if the Diving Medical Officer feels that transferring them to a medical facility immediately is in their best interest.

20-8.3 Flying After Treatments. 0atients with residual symptoms should fly only with the concurrence of a Diving Medical Officer. 0atients who have been treated for decompression sickness or arterial gas embolism and have complete relief should not fly for 72 hours after treatment, at a minimum.

Tenders on Treatment Tables 5, 6, 6A, 1A, 2A, or 3 should have a 24-hour surface interval before flying. Tenders on Treatment Tables 4, 7, and 8 should not fly for 72 hours.

20-8.3.1 **Emergency Air Evacuation.** Some patients will require air evacuation to another treatment or medical facility immediately after surfacing from a treatment. They will not meet surface interval requirements as described above. Such evacuation is done only on the recommendation of a Diving Medical Officer. Aircraft pressurized to one ata should be used if possible, or unpressurized aircraft flown as low as safely possible (no more than 1,000 feet is preferable). Have the patient breathe 100 percent oxygen during transport, if available. If available, an Emergency Evacuation Hyperbaric Stretcher to maintain the patient at 1ata may be used.

20-8.4 Treatment of Residual Symptoms. After completion of the initial recompression treatment and after a surface interval sufficient to allow complete medical evaluation, additional recompression treatments may be instituted. If additional recompression treatments are indicated a Diving Medical Officer must be consulted. Residual symptoms may remain unchanged during the first one or two treatments. In these cases, the Diving Medical Officer is the best judge as to the number of recompression treatments. Consultation with NEDU or NDSTC may be appropriate. As the delay time between completion of initial treatment and the beginning of follow-up hyperbaric treatments increases, the probability of benefit from additional treatments decreases. However, improvement has been noted in patients who have had delay times of up to 1 week. Therefore, a long delay is not necessarily a reason to preclude follow-up treatments. Once residual symptoms respond to additional recompression treatments, such treatments should be continued until no further benefit is noted. In general, treatment may be discontinued if there is no further sustained improvement on two consecutive treatments.

For persistent Type II symptoms, daily treatment on Table 6 may be used, but twice-daily treatments on Treatment Tables 5 or 9 may also be used. The treatment table chosen for re-treatments must be based upon the patient's medical condition and the potential for pulmonary oxygen toxicity. 0atients surfacing from Treatment Table 6A with extensions, 4, 7, or 8 may have severe pulmonary oxygen toxicity and may find breathing 100 percent oxygen at 45 or 60 feet to be uncomfortable. In these cases, daily treatments at 30 feet may also be used. As many oxygen breathing periods (25 minutes on oxygen followed by 5 minutes on air) should be administered as can be tolerated by the patient. Ascent to the surface is at 20 feet per minute. A minimum oxygen breathing time is 10 minutes. A practical maximum bottom time is 3 to 4 hours at 30 feet. Treatments should not be administered on a daily basis for more than 5 days without a break of at least 1 day. These guidelines may have to be modified by the Diving Medical Officer to suit individual patient circumstances and tolerance to oxygen as measured by decrements in the patient's vital capacity.

20-8.5 Returning to Diving after Recompression Treatment. Divers diagnosed with Type I DCS may be medically cleared to return to diving duty 7 days after successful completion of hyperbaric treatment by a DMO. Divers diagnosed with AGE or Type II DCS may be medically cleared to return to diving duty 30 days after initial diagnosis and treatment by a DMO, if initial hyperbaric treatment is successful and no neurologic deficits persist. A BUMED waiver for return to diving is required if symptoms persist beyond initial treatment of AGE or Type II DCS. Refer to Bureau of Medicine and Surgery Manual (MANMED) 0117 Article 15-102 for guidance.

20-9 NON-STANDARD TREATMENTS

The treatment recommendations presented in this chapter should be followed as closely as possible unless it becomes evident that they are not working. Only a Diving Medical Officer may then recommend changes to treatment protocols or use treatment techniques other than those described in this chapter. Any modifications to treatment tables shall be approved by the Commanding Officer. The standard treatment procedures in this chapter should be considered minimum treatments. Treatment procedures should never be shortened unless emergency situations arise that require chamber occupants to leave the chamber early, or the patient's medical condition precludes the use of standard U.S. Navy treatment tables.

20-10 RECOMPRESSION TREATMENT ABORT PROCEDURES

Once recompression therapy is started, it should be completed according to the procedures in this chapter unless the diver being treated dies or unless continuing the treatment would place the chamber occupants in mortal danger or in order to treat another more serious medical condition.

20-10.1 Death During Treatment. If it appears that the diver being treated has died, a Diving Medical Officer shall be consulted before the treatment is aborted. Once the decision to abort is made, there are a number of options for decompressing the tenders depending on the depth at which the death occurred and the preceding treatment profile.

- If death occurs following initial recompression to 60, 165, or 225 on Treatment Tables 6, 6A, 4 or 8, decompress the tenders on the Air/Oxygen schedule in the Air Decompression Table having a depth exactly equal to or deeper than the maximum depth attained during the treatment and a bottom time equal to or longer than the total elapsed time since treatment began. The Air/Oxygen schedule can be used even if gases other than air (i.e., nitrogen-oxygen or helium-oxygen mixtures) were breathed at depth.

- If death occurs after leaving the initial treatment depth on Treatment Tables 6 or 6A, decompress the tenders at 30 fsw/min to 30 fsw and have them breathe oxygen at 30 fsw for the times indicated in Table 20-6. Following completion of the oxygen breathing time at 30 fsw, decompress the tenders on oxygen from 30 fsw to the surface at 1 fsw/min.

- If death occurs after leaving the initial treatment depth on Treatment Tables 4 or 8, or after beginning treatment on Treatment Table 7 at 60 fsw, have the tenders decompress by continuing on the treatment table as written, or consult NEDU for a decompression schedule customized for the situation at hand. If neither option is possible, follow the original treatment table to 60 fsw. At 60 fsw, have the tenders breathe oxygen for 10 min in three 30-min periods separated by a 5-min air break. Continue decompression at 50, 40 and 30 fsw by breathing oxygen for 60 min at each depth. Ascend between stops at 30 fsw/ min. At 50 fsw, breathe oxygen in two 30-min periods separated by a 5-min air break. At 40 and 30 fsw, breathe oxygen for the full 60-min period followed by a 15-min air break. Ascend to 20 fsw at 30 fsw/min and breathe oxygen for 120 min. Divide the oxygen time at 20 fsw into two 60-min periods separated by a 15 min air break. When oxygen breathing time is complete at 20 fsw, ascend to the surface at 30 fsw/min. Upon surfacing, observe the tenders carefully for the occurrence of decompression sickness.

20-10.2 Impending Natural Disasters or Mechanical Failures. Impending natural disasters or mechanical failures may force the treatment to be aborted. For instance, the ship where the chamber is located may be in imminent danger of sinking or a fire or explosion may have severely damaged the chamber system to such an extent that completing the treatment is impossible. In these cases, the abort procedure described in paragraph 20-10.1 could be used for all chamber occupants (including the stricken diver) if time is available. If time is not available, the following may be done:

1. If deeper than 60 feet, go immediately to 60 feet.

2. Once the chamber is 60 feet or shallower, put all chamber occupants on continuous 100 percent oxygen. Select the Air/Oxygen schedule in the Air Decompression Table corresponding to the maximum depth attained during treatment and the total elapsed time since treatment began.

3. If at 60 fsw, breathe oxygen for period of time equal to the sum of all the decompression stops 60 fsw and deeper in the Air/Oxygen schedule, then continue decompression on the Air/Oxygen schedule, breathing oxygen continuously. If shallower than 60 fsw, breathe oxygen for a period of time equal to the sum of all the decompression stops deeper than the divers current depth, then continue decompression on the Air/Oxygen schedule, breathing oxygen continuously. Complete as much of the Air/Oxygen schedule as possible.

4. When no more time is available, bring all chamber occupants to the surface (try not to exceed 10 feet per minute) and keep them on 100 percent oxygen during evacuation, if possible.

5. Immediately evacuate all chamber occupants to the nearest recompression facility and treat according to Figure 20-1. If no symptoms occurred after the treatment was aborted, follow Treatment Table 6.

20-11 ANCILLARY CARE AND ADJUNCTIVE TREATMENTS

WARNING **Drug therapy shall be administered only after consultation with a Diving Medical Officer by qualified inside tenders adequately trained and capable of administering prescribed medications.**

Most U.S. military diving operations have the unique advantage over most other diving operations with the ability to provide rapid recompression for the victims of decompression sickness (DCS) and arterial gas embolism (AGE). When stricken divers are treated without delay, the success rate of standard recompression therapy is extremely good.

Some U.S. military divers, such as Special Operations forces, however, may not have the benefit of a chamber nearby. Diving missions in Special Operations are often conducted in remote areas and may entail a lengthy delay to recompression therapy in the event of a diving accident. Delays to treatment for DCS and AGE significantly increase the probability of severe or refractory disease. In these divers, the use of adjunctive therapy (treatments other than recompression on a treatment table) can be provided while the diver is being transported to a chamber. Adjunctive therapies may also be useful for divers with severe symptoms or who have an incomplete response to recompression and hyperbaric oxygen.

Note that the adjunctive therapy guidelines are separated by accident type, with DCS and AGE covered separately. Although there is some overlap between the guidelines for these two disorders (as with the recompression phase of therapy), the best adjunctive therapy for one disorder is not necessarily the best therapy for the other. Although both DCS and AGE have in common the presence of gas bubbles in the body and a generally good response to recompression and hyperbaric oxygen, the underlying pathophysiology is somewhat different.

20-11.1 Decompression Sickness.

20-11.1.1 **Surface Oxygen.** Surface oxygen should be used for all cases of DCS until the diver can be recompressed. Use of either a high-flow (15 liters/minute) oxygen source with a reservoir mask or a demand valve can achieve high inspired fractions of oxygen. One consideration in administering surface oxygen is pulmonary oxygen toxicity. 100% oxygen can generally be tolerated for up to 12 hours. The patient may be given air breaks as necessary. If oxygen is being administered beyond this time, the decision to continue must weigh the perceived benefits against the risk of pulmonary oxygen toxicity. This risk evaluation must consider the dose of oxygen anticipated with subsequent recompression therapy as well.

20-11.1.2 **Fluids.** Fluids should be administered to all individuals suffering from DCS unless suffering from the chokes (pulmonary DCS). Oral fluids (half-strength glucose and electrolyte solutions) are acceptable if the diver is able to tolerate them. There is no data available that demonstrates a superiority of crystalloids (normal saline or Lactated Ringers solution) over colloids (such as Hetastarch compounds (Hespan or Hextend)) or vice versa, but D5W (dextrose in water without electrolytes) should not be used. Since colloids are far more expensive than Lactated Ringers or normal saline, the latter two agents are the most reasonable choice at this time. The optimal amount of crystalloids/colloids is likewise not well-established but treatment should be directed towards reversing any dehydration that may have been induced by the dive (immersion diuresis causes divers to lose 250-500 cc of fluids per hour) or fluid shifts resulting from the DCS. Fluid overloading should be avoided. Urinary output, in the range of 0.5cc/kg/hour is evidence of adequate intravascular volume.

Chokes (pulmonary DCS) causes abnormal pulmonary function and leakage of fluids into the alveolar spaces. Aggressive fluid therapy may make this condition worse. Consult a DMO (or NEDU) for guidance.

20-11.1.3 **Anticoagulants.** Since some types of DCS may increase the likelihood of hemorrhage into the tissues, anticoagulants should not be used routinely in the treatment of DCS. One exception to this rule is the case of lower extremity weakness. Low molecular weight heparin (LMWH) should be used for all patients with inability to walk due to any degree of lower extremity paralysis caused by neurological DCS or AGE. Enoxaparin 30 mg, or its equivalent, administered subcutaneously every 12 hours, should be started as soon as possible after injury to reduce the risk of deep venous thrombosis (DVT) and pulmonary embolism in paraplegic patients. 0lastic stockings or intermittent pneumatic compression are alternatives, although they are less effective at preventing DVT than LMWH.

20-11.1.4 **Aspirin and Other Non-Steroidal Anti-Inflammatory Drugs.** Routine use of anti- platelet agents in patients with neurological DCS is not recommended, due to concern about worsening hemorrhage in spinal cord or inner ear decompression illness. Use of these agents may also be risky in combat divers who may be required to return to action after treatment of an episode of DCS.

20-11.1.5 **Steroids.** Steroids are no longer recommended for the treatment of DCS. No significant reduction in neurological residuals has been found in clinical studies for DCS adjunctively treated with steroids and elevated blood glucose levels associated with steroid administration may actually worsen the outcome of CNS injury.

20-11.1.6 **Lidocaine.** Lidocaine is not currently recommended for the treatment of any type of DCS.

20-11.1.7 **Environmental Temperature.** For patients with evidence of brain or spinal cord damage, the current evidence recommends aggressive treatment of elevated body temperature. When treating victims of neurological DCS, whenever practical, hot environments that may cause elevation of body temperature above normal should be avoided. The patient's body temperature and vital signs should be monitored regularly.

20-11.2 Arterial Gas Embolism.

20-11.2.1 **Surface Oxygen.** Surface oxygen should be used for all cases of AGE as it is for DCS.

20-11.2.2 **Lidocaine.** Lidocaine has been shown to be useful in the treatment of AGE. If it is to be used clinically, evidence suggests that an appropriate end-point is attainment of a serum concentration suitable for an anti-arrhythmic effect. An intravenous initial dose of 1 mg/kg followed by a continuous infusion of 2-4 mg/minute, will typically produce therapeutic serum concentrations. If an intravenous infusion is not established, intramuscular administration of 4-5 mg/kg will typically produce a therapeutic plasma concentration 15 minutes after dosing, lasting for around 10 minutes. Doses greater than those noted above may be associated with major side effects, including paresthesias, ataxia, and seizures.

20-11.2.3 **Fluids.** The fluid replacement recommendations for the treatment of AGE differ from those of DCS. The pathophysiology of the lesion (pulmonary barotrauma vs. tissue supersaturation with in-situ gas formation) is not the issue. The major difference in the recommendations for fluid therapy in AGE vs. DCS are because divers who suffer AGE may be less dehydrated than divers with DCS, either because they have had a shorter period of immersion or because they have had less bubble-induced endothelial damage. In addition, the CNS injury in AGE may be complicated by cerebral edema and an increased fluid load may worsen this cerebral edema and cause further injury to the diver. If fluids are used, crystalloids are probably the best choice for the reasons previously noted in the section on adjunctive therapy of DCS. 0articular care should be taken not to overload the diver with fluids by adjusting IV rates to maintain just an adequate urine output of 0.5cc/kg/hour. A urinary catheter should be inserted in the unconscious patient and urinary output measured.

20-11.2.4 **Anticoagulants.** Anticoagulants should not be used routinely in the treatment of AGE. As noted previously in paragraph 20-11.1.3 on anticoagulants in DCS, Enoxaparin 30 mg, or its equivalent, should be administered subcutaneously every 12 hours, after initial recompression therapy in patients suffering from paralysis to prevent deep venous thrombosis (DVT) and pulmonary embolism.

20-11.2.5 **Aspirin and Other Non-Steroidal Anti-Inflammatory Drugs.** Routine use of anti- platelet agents in patients with AGE is not recommended.

20-11.2.6 **Steroids.** Steroids are no longer recommended for the treatment of AGE. No significant reduction in neurologic residual has been shown with adjunctive treatment with steroids for AGE and elevated blood glucose levels associated with administration of steroids may worsen the outcome of CNS injury.

20-11.3 Sleeping and Eating. The only time the patient should be kept awake during recompression treatments is during oxygen breathing periods at depths greater than 30 feet. Travel between decompression stops on Treatment Table 4, 7, and 8 is not a contra-indication to sleeping. While asleep, vital signs (pulse, respiratory rate, blood pressure) should be monitored as the patient's condition dictates. Any significant change would be reason to arouse the patient and ascertain the cause. Food may be taken by chamber occupants at any time. Adequate fluid intake should be maintained as discussed in paragraph 20-7.5.1.

20-12 EMERGENCY MEDICAL EQUIPMENT

Every diving activity shall maintain emergency medical equipment that will be available immediately for use in the event of a diving accident. This equipment is to be in addition to any medical supplies maintained in a medical treatment facility and shall be kept in a kit small enough to carry into the chamber, or in a locker in the immediate vicinity of the chamber.

20-12.1 Primary and Secondary Emergency Kits. Because some sterile items may become contaminated as a result of a hyperbaric exposure, it is desirable to have a primary kit for immediate use inside the chamber and a secondary kit from which items that may become contaminated can be locked into the chamber only as needed. The primary emergency kit contains diagnostic and therapeutic equipment that is available immediately when required. This kit shall be inside the chamber during all treatments. The secondary emergency kit contains equipment and medicine that does not need to be available immediately, but can be locked-in when required. This kit shall be stored in the vicinity of the chamber.

The contents of the emergency kits presented here are not meant to be restrictive but are considered the minimum requirement. Additional items may be added to suit local medical preferences.

The primary Emergency Kit is described in Table 20-7. The Secondary Emergency Kit is described in Table 20-8.

Table 20-7. *Primary Emergency Kit.*

Diagnostic Equipment

- Stethoscope
- Otoscope (Ophthalmoscope optional) and batteries
- Sphygmomanometer (aneroid type only, case vented for hyperbaric use)
- Reflex Hammer
- Tuning Fork
- Pinwheel
- Tongue depressors
- Thermometer/temperature measurement capability (non-mercury type)
- Pulse Oximeter (Nonin 9500/8500 series)
- Disposable exam gloves Skin Marker
- Pocket Eye Chart (Snellen)

Emergency Treatment Primary Survey Equipment and Medications

- Oropharyngeal airways (#4 and #5 Guedel-type or equivalent)
- Nasal airways (#32F and #34F latex rubber)
- Lidocaine jelly (2%)
- Self-Inflating Bag-Valve Mask (Disposable 6VM)
- Suction apparatus with appropriate suction tips
- Tension pneumothorax relief with 3.25 inch, large-bore catheter on a needle
- Cricothyrotomy kit
- Adhesive tape F2 inch waterproof)
- Elastic-strap bandage for a pressure bandage (2 and 4 inch) Pressure dressing
- Appropriate Combat Tourniquet Trauma Scissors
- Sterile 4X4s
- Cravats

NOTE: One Primary Emergency Kit is required per chamber system, e.g. TNCS requires one. Additional Medical Equipment Authorized for Military Use (AMU) in a chamber can be found in the Medical Equipment section of the AMU on the NAVSEA website. Contact the Senior Medical Officer at the Navy Experimental Diving Unit for any questions regarding specific pieces of medical equipment for use in the chamber.

Table 20-8. *Secondary Emergency Kit.*

Emergency Treatment Secondary Survey Equipment and Medications

- Alternative emergency airway device (recommend intubating laryngeal mask airway disposable LMA Fastrach™kit, size 4 – 5)
- Syringe and sterile water for cuff inflation (10 cc) Sterile lubricant
- Qualitative end-tidal CO_2 detector (colorimetric indicator)
- Chest tube
- BD Bard Parker Heimlich Chest Drain Valve For other device to provide one-way flow of gas out of the chest)
- #11 knife blade and handle Sterile gloves (size 6 – 8) Surgical masks (4)
- 10% povidone-iodine swabs or wipes
- 1% lidocaine solution
- 21 gauge. 1 ½ -inch needles on 5 cc syringes (2)
- Curved Kelly forceps

Intravenous Infusion Therapy

- Catheter on a needle unit, intravenous (16 and 18 gauge 9 4 ea)
- Adult interosseous infusion device (IO) for rapid vascular access
- Intravenous infusion sets (2 standard drip and 2 micro-drip)
- Syringes (5, 10 and 30 cc)
- Sterile needles (18, 22 and 25 gauge)
- Normal saline (1 liter bag F4))
- IV Start Kit (10% Povidone-Iodine swabs or wipes, 2 x 2 gauze sponges, Bioclusive dressing, ¾ -inch adhesive tape, phlebotomy tourniquet)
- Band aids
- Sam™ Splint

Miscellaneous

- Nasogastric tube
- 60 cc Toomey Syringe (Optional)
- Urinary catheterization set with collection bag (appropriate size F12F-14F) Foley-type sterile catheters)
- Assorted suture material (0-silk with and without curved needles)
- Sharps disposable box
- Disposable Minor Surgical Tray can substitute for items listed below:
    - Straight and curved hemostats (2 of each)
    - Blunt straight surgical scissors
    - Needle driver
    - Sterile towels Sterile gauze pads

NOTE 1: Whenever possible, preloaded syringe injection sets should be obtained to avoid the need to vent multi9dose vials or prevent implosion of ampules. Sufficient quantities should be maintained to treat one injured diver.

NOTE 2: One Secondary Emergency Kit is required per chamber system (i.e., TNCS requires one).

NOTE 3: A portable oxygen supply with an E cylinder (approximately 669 liters of oxygen) with a regulator capable of delivering 12 liters of oxygen per minute by mask/reservoir or 2 liters by nasal canula is recommended whenever possible in the event the patient needs to be transported to another facility.

20-12.2 Portable Monitor-Defibrillator. All diving activities/commands shall maintain an automated external defibrillator (AED), preferably with heart rhythm visualization capability, from an approved Authorized Medical Allowance List (AMAL). Diving activities with assigned Diving Medical Officer are recommended to augment with a fully capable monitor defibrillator.

CAUTION AED's are not currently approved for use under pressure (hyperbaric environment) due to electrical safety concerns.

20-12.3 Advanced Cardiac Life Support (ACLS) Drugs and Equipment. All commands with chambers that participate in area bends watch shall maintain those drugs recommended by the American Heart Association for ACLS. These drugs need to be in sufficient quantities to support an event requiring Advanced Cardiac Life Support. These drugs are not required to be in every dive kit when multiple chambers/kits are present in a single command. In addition, medications for the treatment of anaphylaxis, which can occur related to marine life envenomation, including Epinephrine 1:1000 solution, Diphenhydramine IM or PO and Hydrocortisone Sodium Succinate IV will be maintained in adequate quantities to treat one patient.

Emergency medical equipment in support of ACLS includes cuffed endotracheal tubes with adapters (7-8 mm), malleable stylet (approx. 12" in length), laryngoscope with blades (McIntosh 93 and 94, Miller 92 and 93). Additional mechanical devices for verification of endotracheal tube placement are also authorized, but not required (Toomey-type or 50cc catheter tip syringe or equivalent).

NOTE Some vendors supply pre-packed ACLS kits with automated replenishment programs (examples of which can be found on the Naval Expeditionary Combat Command (NECC) AMAL).

20-12.4 Use of Emergency Kits. Unless adequately sealed against increased atmospheric pressure (i.e., vacuum packed), sterile supplies should be re-sterilized after each pressure exposure; or, if not exposed, at package expiration date. Drugs shall be replaced when their expiration date is reached. Not all drug ampules will withstand pressure.

NOTE Stoppered multi-dose vials with large air volumes may need to be vented with a needle during pressurization and depressurization and then discarded.

Both kits should be taken to the recompression chamber or scene of the accident. Each kit is to contain a list of contents and have a tamper evident seal. Each time the kit is opened, it shall be inventoried and each item checked for proper working order and then re-sterilized or replaced as necessary. Unopened kits are inventoried quarterly. Concise instructions for administrating each drug are to be provided in the kit along with current American Heart Association Advanced Cardiac Life-Support Protocols. In untrained hands, many of the items can be dangerous. Remember that as in all treatments **YOUR FIRST DUTY IS TO DO NO HARM.**

Appendix 7: U.S. Navy Diving Manual – Chapter 21

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CHAPTER 21

Recompression Chamber Operation

21-1 INTRODUCTION

21-1.1 Purpose. This chapter will familiarize personnel with the maintenance and operational requirements for recompression chambers.

21-1.2 Scope. Recompression chambers are used for the treatment of decompression sickness and arterial gas embolism, for surface decompression, and for administering pressure tests to prospective divers. Recompression chambers equipped for hyperbaric administration of oxygen are also used in medical facilities for hyperbaric treatment of carbon monoxide poisoning, gas gangrene, and other diseases. Double-lock chambers are used because they permit personnel and supplies to enter and leave the chamber during treatment.

21-1.3 Chamber Requirements. The requirements for recompression chamber availability are covered in paragraph 6-5.15 and repeated below in Table 21-1.

Table 21-1. *Navy Recompression Chamber Support Levels*

RCC Support Level	Definition
Level I	A U.S. Navy certified recompression chamber close enough to the dive site to support surface decompression with a surface interval of 5 minutes. (Notes 1, 2)
Level II	A U.S. Navy certified recompression chamber accessible within one hour of the casualty. (Note 2)
Level III	A U.S. Navy certified recompression chamber accessible within six hours of the casualty. (Note 3, 4)
Note 1. Based on space constraints at the site, the Commanding Officer may authorize extension of the surface interval to a maximum of 7 minutes in accordance with Paragraphs 9-12.6 and 14-4.14. Note 2. A non-Navy chamber may be used to satisfy this requirement if approved in writing by the CNO. Note 3. A non-Navy chamber may be used to satisfy this requirement if approved in writing by the Commanding Officer. Note 4. During extreme circumstances when a chamber cannot be reached within 3 hours the Commanding Officer can give authorization to use the nearest approved recompression facility.	

21-2 DESCRIPTION

Most chamber-equipped U.S. Navy units will have one of seven commonly provided chambers. They are:

1. Double-lock, 200-psig, 425-cubic-foot steel chamber (Figure 21-1).
2. Recompression Chamber Facility: RCF 6500 (Figure 21-2).
3. Recompression Chamber Facility: RCF 5000 (Figure 21-3).
4. Double-lock, 100-psig, 202-cubic-foot steel chamber (ARS 50 class and Modernized) (Figure 21-4 and Figure 21-5).
5. Standard Navy Double Lock Recompression Chamber System (SNDLRCS) (Figure 21-6).
6. Transportable Recompression Chamber System (TRCS) (Figure 21-7, Figure 21-8, Figure 21-9).
7. Fly-Away Recompression Chamber (FARCC) (Figure 21-10, Figure 21-11, Figure 21-12).

Select U.S. Navy units have a unique treatment option called the Emergency Evacuation Hyperbaric Stretcher (EEHS). The EEHS has a single lock and allows a patient to be administered oxygen at 60 feet while in transport to a recompression chamber. However, it does not provide hands-on access to the patient and therefore does not qualify as a recompression chamber.

21-2.1 Basic Chamber Components. The basic components of a recompression chamber are much the same from one model to another. The basic components consist of the pressure vessel itself, an air supply and exhaust system, a pressure gauge, and a built-in breathing system (BIBS) to supply oxygen to the patient. Additional components may include oxygen, carbon dioxide, temperature and humidity monitors, carbon dioxide scrubbers, additional BIBS systems for air and treatment gases other than oxygen, a BIBS overboard dump system, and a heating/cooling system. Collectively these systems must be able to impose and maintain a pressure equivalent to a depth of 165 fsw (6 atmospheres absolute) on the diver. Double- lock chambers are used because they permit tending personnel and supplies to enter and leave the chamber during treatment.

The piping and valving on some chambers is arranged to permit control of the air supply and the exhaust from either the inside or the outside of the chamber. Controls on the outside must be able to override the inside controls in the event of a problem inside the chamber. The usual method for providing this dual-control capability is through the use of two separate systems. The first, consisting of a supply line and an exhaust line, can only be controlled by valves that are outside of the chamber. The second air supply/exhaust system has a double set of valves, one inside and one outside the chamber. This arrangement permits the tender to regulate descent or ascent from within the chamber, but always subject to final control by outside personnel.

21-2.2 Fleet Modernized Double-Lock Recompression Chamber. Modernized chambers (Figure 21-5) have carbon dioxide and oxygen monitors, a CO_2 scrubber system, a Built-In Breathing System (BIBS), and an oxygen dump system which together reduce the ventilation requirements. These chambers also include a chamber environment control system that regulates humidity and temperature.

21-2.3 Recompression Chamber Facility (RCF). The RCF series 6500 and 5000 (Figures 21-2 and 21-3) consists of two sizes of standard double lock steel chambers, each with a medical lock and easy occupant access. The RCF 6500 is capable of treating up to 12 occupants while the RCF 5000 is capable of treating 7 occupants. The systems are installed in a facility to support training, surface decompression, recompression treatment, and medical treatment operations. Each RCF includes primary and secondary air supplies comprised of compressors, purification, and storage for chamber pressurization and ventilation along with oxygen, mix treatment gas, and emergency air supply to the BIBS system. Each RCF has an atmospheric conditioning system that provides internal atmospheric scrubbing and monitoring along with temperature and humidity controls for long term treatment, gas management, and patient comfort. The RCF includes gas supply monitoring, a fire extinguishing system, ground fault interruption and emergency power. The RCF 6500 is equipped with a NATO mating flange. Both series have extra penetrations for auxiliary equipment such as patient treatment monitoring and hoods.

21-2.4 Standard Navy Double Lock Recompression Chamber System (SNDLRCS). The SNDLRCS (Figure 21-6) consists of a Standard Navy Double Lock (SNDL) recompression chamber and a gas supply system housed within an International Organization for Standards (ISO) container. The system is capable of supporting surface decompression, medical treatment, and training operations. Air is supplied to the system using a Air Flask Rack Assembly (AFRA) which is almost identical to the Air Supply Rack Assembly (ASRA) used in supporting a FADS 3 DLSS. Oxygen is provided by four (4) cylinders that are secured to the interior bulkhead of the ISO container. If an external supply of mixed gas is available it can also be supplied to the chamber BIBS supply.

The SNDL is a 54" diameter, double lock recompression chamber. It is outfitted with a stretcher, BIBS, gas monitoring systems, lights, and an environmental conditioning system. The chamber can comfortably accommodate 4 divers in the inner lock and 3 divers in the outer lock.

The ISO container houses the gas supply systems and the chamber. It also provides a shelter from environmental elements for the Outside Tenders and Diving Supervisor to conduct treatments. The container is both heated and air conditioned as required and also includes a fold-down desktop, a cabinet, lighting, and a vestibule.

21-2.5 Transportable Recompression Chamber System (TRCS). There are three TRCS Mods.

- TRCS Mod 0 (Figure 21-7) consists of two pressure chambers. One is a conical-shaped chamber (Figure 21-8) called the Transportable Recompression Chamber (TRC) and the other is a cylindrical shaped vessel (Figure 21-9) called the Transfer Lock (TL). The two chambers are capable of being connected by means of a freely rotating NATO female flange coupling (Figure P1-W).

- TRCS Mod 1 consists of just the TRC.

- TRCS Mod 2 is the TRCS Mod 0 which has had the 5000 psi upgrade ECP installed allowing it to be used with an Air Supply Rack Assembly (ASRA).

The TRCS is supplied with a Compressed Air and Oxygen System (CAOS) consisting of lightweight air and oxygen racGs of high pressure flasGs, as well as a means of reducing oxygen supply pressure. The TRCS Mod 2 can use the TRCS Mod 0 lightweight air racks rated at 3000 psi or an ASRA rated at 5000 psi. The chamber is capable of administering oxygen and mixed gas via BIBS.

An ECP upgrade is available for installing a CO_2 Scrubber in the TL. A TRCS Mod 0 or Mod 2 without a TL CO_2 Scrubber is limited to one patient and one tender.
When a Level I Recompression Chamber is required or Surface Decompression dives are planned, a TRCS Mod 0 or Mod 2 (with TL CO_2 Scrubber installed) can be used.

When a Level I Recompression Chamber is not required, any of the three TRCS Mods can be used.

21-2.6 Fly Away Recompression Chamber (FARCC). This chamber system consists of a 60-inch double lock modernized chamber in a 20' x 8' x 8' milvan (Figure 21-10 and Figure 21-11). The Fly Away Recompression Chamber (FARCC) also includes a life support skid (Figure 21-12). In addition, a stand-alone generator is provided for remote site power requirements.

21-2.7 Emergency Evacuation Hyperbaric Stretcher (EEHS). The Emergency Evacuation Hyperbaric Stretcher (EEHS) is a manually-portable single patient hyperbaric tube to be used to transport a diving or disabled submarine casualty from an accident site to a treatment facility while under pressure. The EEHS does not replace a recompression chamber, but is used in conjunction with a chamber. The EEHS is small enough to allow transfer of a patient, under pressure, into or out of many shore based recompression chambers owned by both the DOD, and civilian medical organizations.

21-2.8 Standard Features. Recompression chambers must be equipped with a means for delivering breathing oxygen to the personnel in the chamber. The inner lock should be provided with connections for demand-type oxygen inhalators. Oxygen can be furnished through a pressure reducing manifold connected with supply cylinders outside the chamber.

21-2.8.1 **Labeling.** All lines should be identified and labeled to indicate function, content and direction of flow. The color coding in Table 21-2 should be used.

21-2.8.2 **Inlet and Exhaust Ports.** Optimum chamber ventilation requires separation of the inlet and exhaust ports within the chamber. Exhaust ports must be provided with a guard device to prevent accidental injury when they are open.

21-2.8.3 **Pressure Gauges.** Chambers must be fitted with appropriate pressure gauges. These gauges, marked to read in feet of seawater (fsw), must be calibrated or compared as described in the applicable Planned Maintenance System (PMS) to ensure accuracy in accordance with the instructions in Chapter 4.

Table 21-2. *Recompression Chamber Line Guide.*

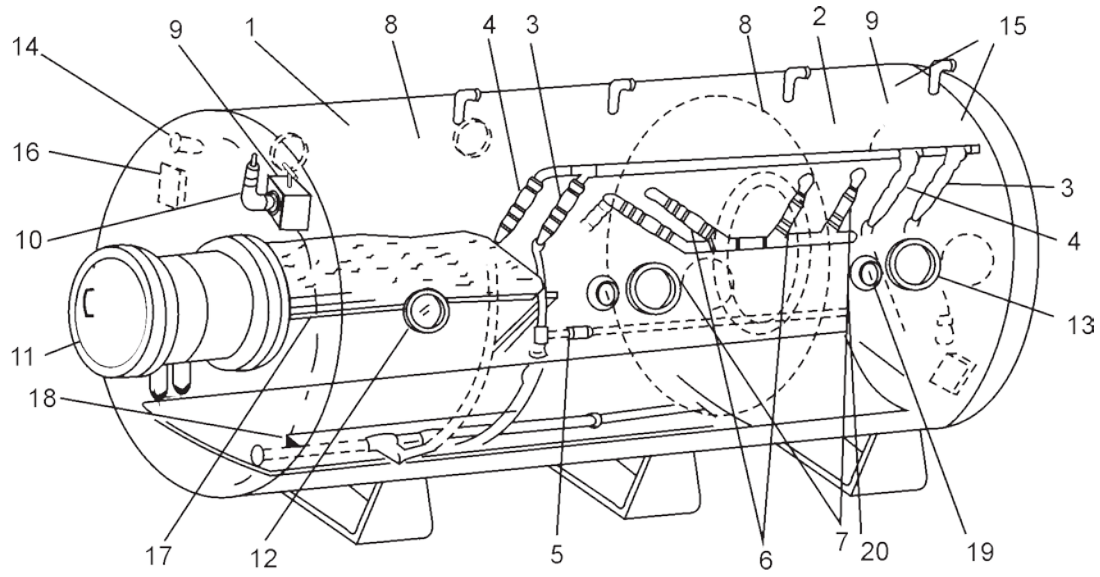
Function	Designation	Color Code
Helium	HE	Buff
Oxygen	OX	Green
Helium-Oxygen Mix	HE-OX	Buff & Green
Nitrogen	N	Light Gray
Nitrogen Oxygen Mix	N-OX	Light Gray & Green
Exhaust	E	Silver
Air (Low Pressure)	ALP	Black
Air (High Pressure)	AHP	Black
Chilled Water	CW	Blue & White
Hot Water	HW	Red & White
Potable Water	PW	Blue
Fire Fighting Material	FP	Red

21-2.8.4 **Relief Valves.** Recompression chambers should be equipped with pressure relief valves in each manned lock. Chambers that do not have latches (dogs) on the doors are not required to have a relief valve on the outer lock. The relief valves shall be set in accordance with PMS. In addition, all chambers shall be equipped with a gag valve, located between the chamber pressure hull and each relief valve. This gag valve shall be a quick acting, ball-type valve, sized to be compatible with the relief valve and its supply piping. The gag valve shall be safety wired in the open position.

21-2.8.5 **Communications System.** Chamber communications are provided through a diver's intercommunication system, with the dual microphone/speaker unit in the chamber and the surface unit outside. The communication system should be arranged so that personnel inside the chamber need not interrupt their activities to operate the system. The backup communications system may be provided by a set of standard sound-powered telephones. The press-to-talk button on the set inside the chamber can be taped down, thus keeping the circuit open.

21-2.8.6 **Lighting Fixtures.** Consideration should be given to installation of a low-level lighting fixture (on a separate circuit), which can be used to relieve the patient of the heat and glare of the main lights. Emergency lights for both locks and an external control station are mandatory. No electrical equipment, other than that authorized within the scope of certification or as listed in the NAVSEA Authorization for Military Use (AMU) List, is allowed inside the chamber. Because of the possibility of fire or explosion when working in an oxygen or compressed air atmosphere, all electrical wiring and equipment used in a chamber shall meet required specifications.

Double-Lock Steel Recompression Chamber

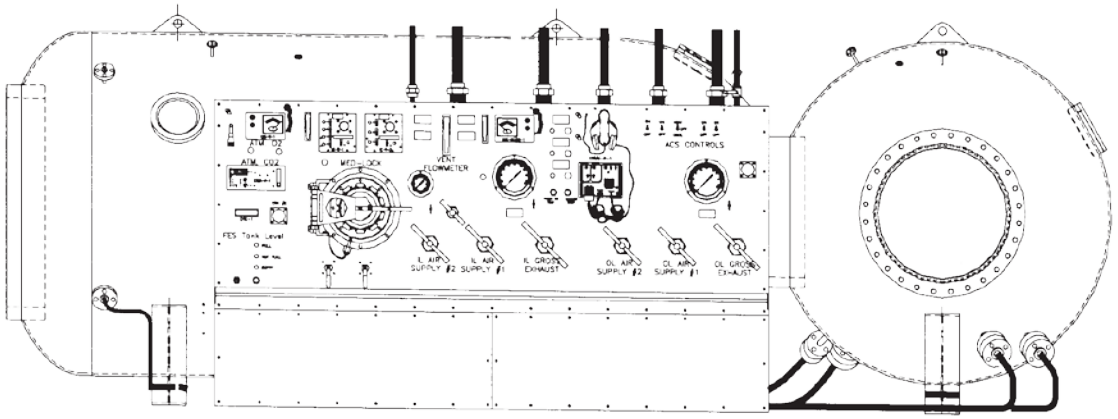


1. Inner Lock
2. Outer Lock
3. Air Supply – Two0Valve
4. Air Supply – One0Valve
5. Main Lock .ressure E4ualizing Valve
3. Exhaust – Two0Valve
-. Exhaust – One0Valve
8. Oxygen Manifold
9. Relief Gag Valve (1 each lock)
10. Relief Valve – 110 psig
11. Medical Lock 180lnch Diameter
12. View .ort – Inner Lock (4)
13. View .ort – Outer Lock (2)
14. Lights – Inner Lock 40 @att (4)
15. Lights – Outer Lock 40 @att
13. Transmitter/Receiver
1-. Berth – 2′6″ × 6′6″
18. Bench
19. .ressure Gauge – Outside (2 each lock)
20. .ressure Gauge – Inside (1 each lock)

Original Design .ressure – 200 psig
Original 9ydrostatic Test .ressure – 400 psig
Maximum Operating .ressure – 100 psig

Figure 21-1. Double-Lock Steel Recompression Chamber.

Recompression Chamber Facility: RCF 6500



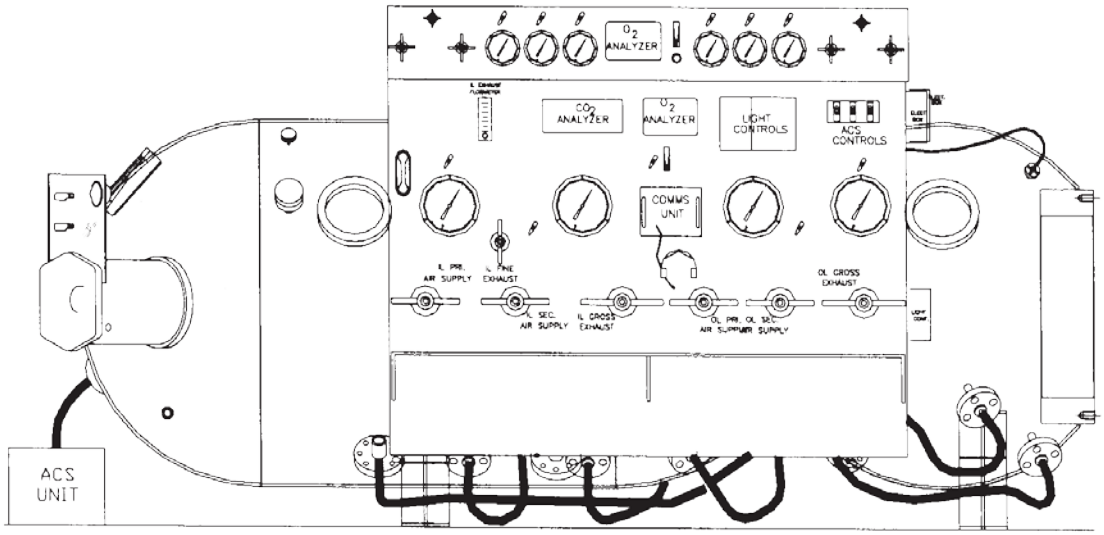
Design Pressure: 110 psig
Length: 21' 3"
Height: –' 3"
Internal Volume (OL): 144 ft^3
Door Opening (OL): 30"

Design Temperature: 00125°F
Diameter: 3' 3"
Height: –' 3"
Internal Volume (IL): 440 ft^3
Door Opening (IL): 48"

Viewports: 6 @ 8" diameter Clear Opening (including 1 video port)
Medlock: 18" diameter X 20" long mounted in console with ASME Quick Actuating Enclosure
Mating Flange: NATO per STANAG 1079
Atmospheric Monitoring: Oxygen, Carbon Dioxide, Temperature
Temperature Monitoring: External Heater/Chiller with internal Blower
Scrubber: Magnetically driven, replaceable canister
BIBS: 8 masks in IL, 4 masks in OL, automatic switching with block & bleed for Oxygen/Nitrox or Heliox/Air, overboard dump, and Oxygen analysis of supply gas
Principal Communications: AC Powered Speaker/9eadset w/battery backup
Secondary Communications: Sound Powered Phone
Furnishing: Two 7' Bunks, One 5' 6" Bench, One 18" X 18" Bench
Lighting: 4 Lights in IL, 2 Lights in OL
Gas Pressurization Controls: Primary and secondary air
Air Ventilation Controls: Gross vent and fine vent (with flow meter)
Fire Extinguishing System: 2 Hand Held Hoses in IL, 1 in OL

Figure 21-2. Recompression Chamber Facility: RCF 3500.

Recompression Chamber Facility: RCF 5000



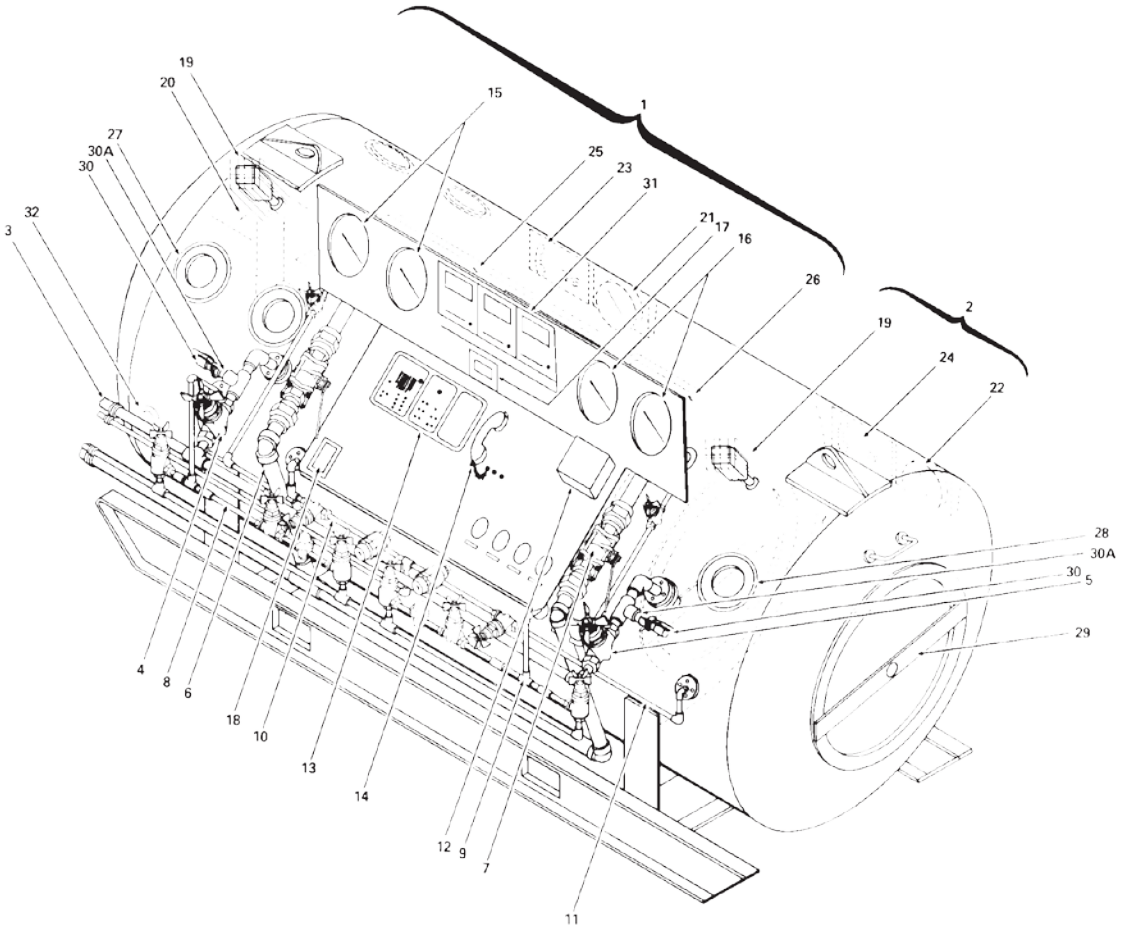
Design Pressure: 110 psig
Length: 14' 8"
Height: 5' 7"
Internal Volume (OL): 61 ft^3
Door Opening (OL): 30"

Design Temperature: 0-125°F
Diameter: 5'
Weight: 9,300 lbs.
Internal Volume (IL): 162 ft^3

Viewports: 3 @ 8" diameter Clear Opening (including 1 video port)
Medlock: 18" diameter X 20" long mounted in console with ASME Quick Actuating Enclosure
Mating Flange: NATO per STANAG 10-9
Atmospheric Monitoring: Oxygen, Carbon Dioxide, Temperature
Temperature Monitoring: External 9eater/Chiller with internal Blower
Scrubber: Magnetically driven, replaceable canister
BIBS: 4 masks in IL, 3 masks in OL, overboard dump, & Oxygen analysis of supply gas
Principal Communications: AC Powered Speaker/Headset w/battery backup
Secondary Communications: Sound Powered .hone
Furnishing: One Bunks, One Bench
Lighting: 2 Lights in IL, 1 Lights in OL
Gas Pressurization Controls: Primary and secondary air
Air Ventilation Controls: Gross vent and fine vent (with flow meter)
Fire Extinguishing System: 9yperbaric extinguisher

Figure 21-3. Recompression Chamber Facility: RCF 5000.

ARS 50 Class Double-Lock Recompression Chamber

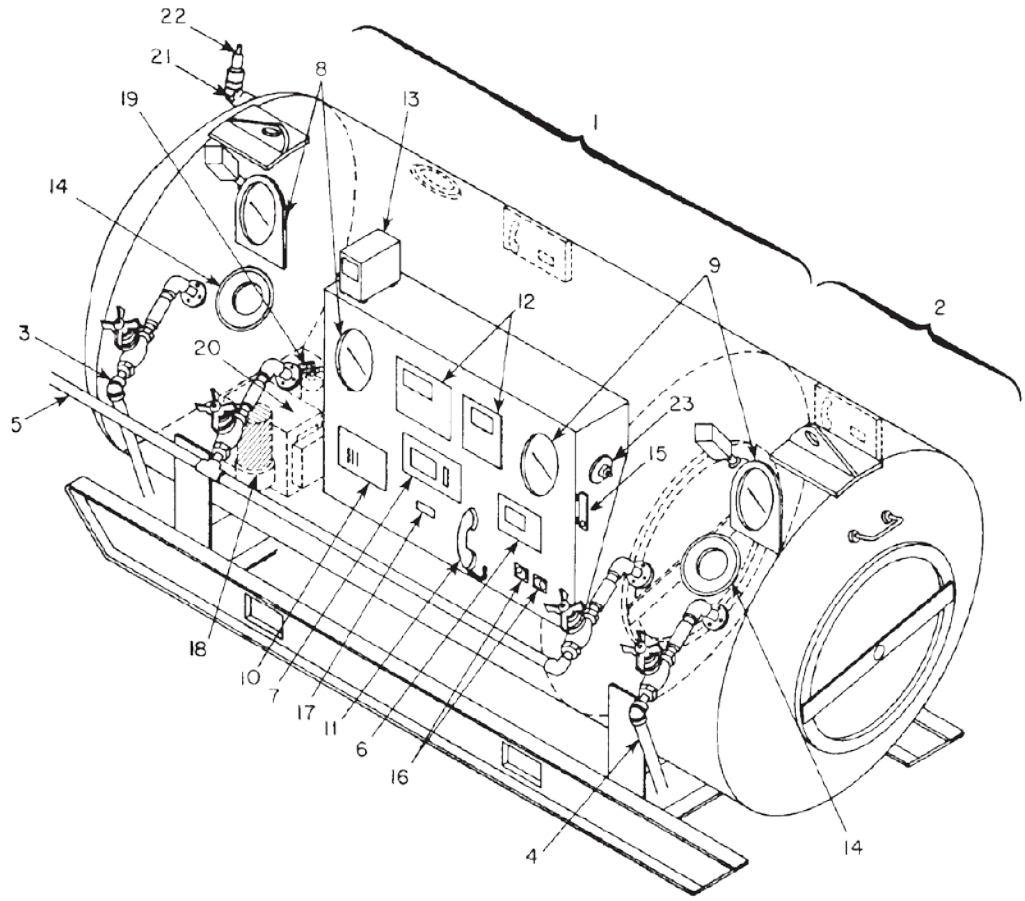


1. Inner Lock
2. Outer Lock
3. Air Supply Connection
4. Air Supply - Inner Lock
5. Air Supply - Outer Lock
3. Exhaust - Inner Lock
-. Exhaust - Outer Lock
8. BIBS Supply - Inner Lock
9. BIBS Supply - Outer Lock
10. BIBS Exhaust - Inner Lock
11. BIBS Exhaust - Outer Lock
12. Oxygen Analyzer
13. Communications
14. Sound0.owered .hones
15. External Depth Gauges - Inner Lock (2)
13. External Depth Gauges - Outer Lock (2)
1-. Telethermometer
18. Ground Fault Interrupter
19. Pipe Light Assembly
20. Chiller and Scrubber Panel
23. Inner Lock Comm Panel
24. Outer Lock Comm Panel
25. Bunk Main
23. Bunk Extension
2-. View .orts - Inner Lock (4)
28. View .orts - Outer Lock (2)
29. Strongback
30. Relief Valve - 100 psig
30A. Gag Valve
31. Pipe Light Controls
32. Chiller/Scrubber Penetrator

Design Pressure - 100 psig
Original Hydrostatic Pressure - 150 psig
Principal Locations - ARS050 Class Salvage Ships

Volume: Inner Lock = 134 cubic feet
Outer Lock = 38 cubic feet
Total = 202 cubic feet

Figure 21-4. Double-Lock Steel Recompression Chamber.



1. Inner Lock
2. Outer Lock
3. Gas Supply – Inner Lock
4. Gas Supply – Outer Lock
5. Gas Exhaust
6. O_2 Analyzer
7. CO_2 Analyzer
8. Inner0Lock Depth Gauges (2)
9. Outer0Lock Depth Gauges (2)
10. Communications Panel
11. Sound-Powered Phone
12. Pipe Light Control Panel
13. Ground Fault Interrupter
14. View ports (5)
15. Flowmeter
16. Stopwatch/Timer
17. Telethermometer
18. CO_2 Scrubber
19. Fire Extinguisher
20. Chiller/Conditioner Unit
21. Gag Valve
22. Relief Valve – 110 psig
23. BIBS Overboard Dump Regulator – Outer Lock

Figure 21-5. Fleet Modernized Double-Lock Recompression Chamber.

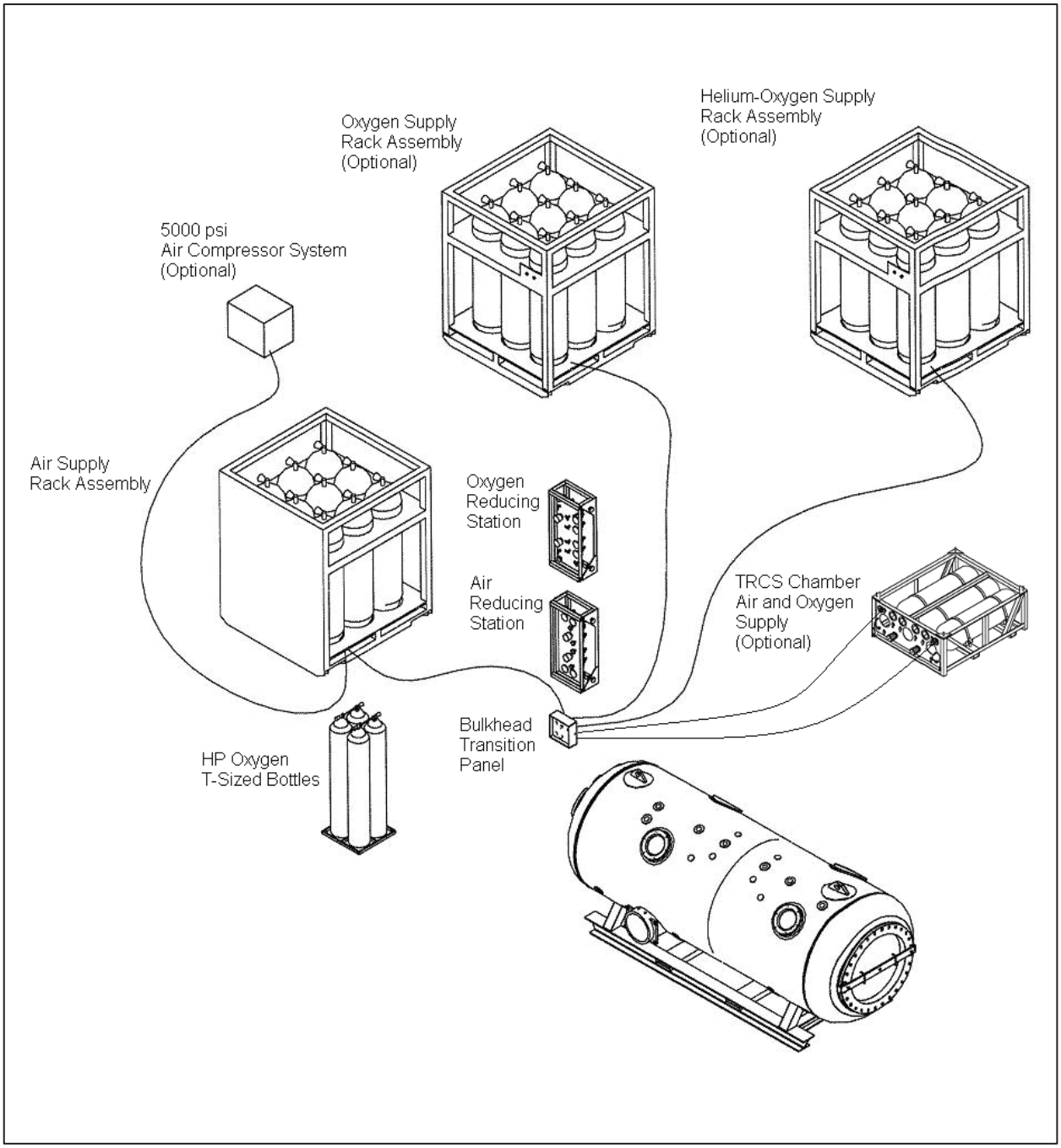


Figure 21-6. Standard Navy Double-Lock Recompression Chamber System.

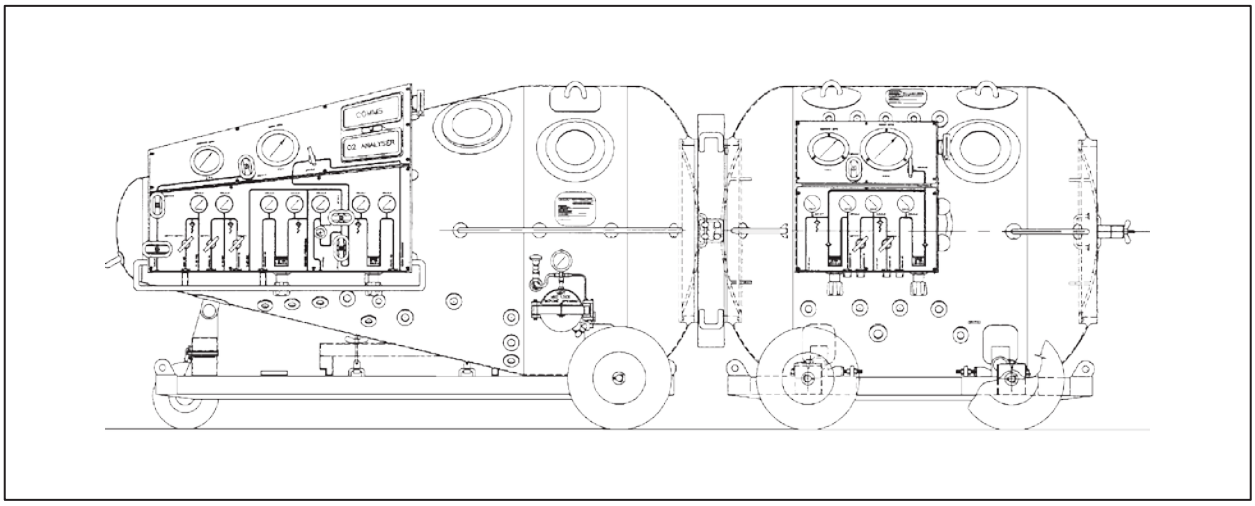
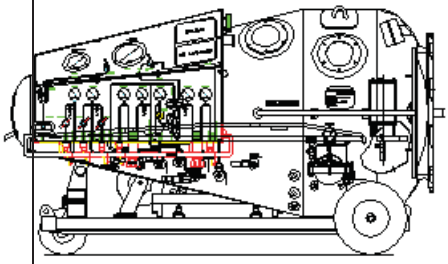


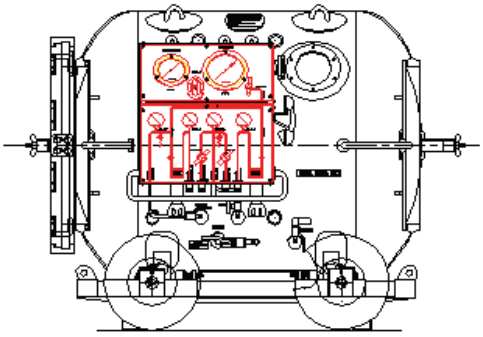
Figure 21-7. Transportable Recompression Chamber System (TRCS).



Design Pressure	110 psig
Design Temperature	0-125°F
Length	95.7”

Height	52” with wheels, 48” without wheels
Width	50.7”
Weight	1,238 lbs.
Internal Volume Door	45 cu. ft.
Opening View Ports	26”
Medical Lock	5.75” dia. x 11.8” long
Mating Flange	Male per NATO STANAG 1079
Life Support Scrubber	Air driven, replaceable scrubber, canister fits in Med Lock
BIBS	2 masks - oxygen and air supply (with capability for N_2O_2 or HeO_2) - overboard dump
Atmospheric Monitoring	Oxygen and Carbon Dioxide Analyzer
Gas Supply	Primary and secondary air and O_2
Communications	Battery-powered speaker/headset phone
Furnishing	Patient litter, attendants seat

Figure 21-8. Transportable Recompression Chamber (TRC).



Height	52.9”
Width	54.8”
Weight	1,337 lbs.
Internal Volume	45.5 cu. ft.
Door Opening	2 doors — 26”
View Ports	2 @ 6” dia. Clear Opening
Mating Flange	Rotating Female per NATO STANAG 1079
Life Support Scrubber	Air-driven, replaceable scrubber, canister fits in TRC Med Lock
BIBS	2 masks - oxygen and air supply - overboard dump
Design Pressure	110 psig
Design Temperature	0-125°F
Length	69.9”
Atmospheric Monitoring	Oxygen and Carbon Dioxide Analyzer
Gas Supply	Primary and secondary air and O_2
Communications	Sound-powered phone

Figure 21-9. Transfer Lock (TL).

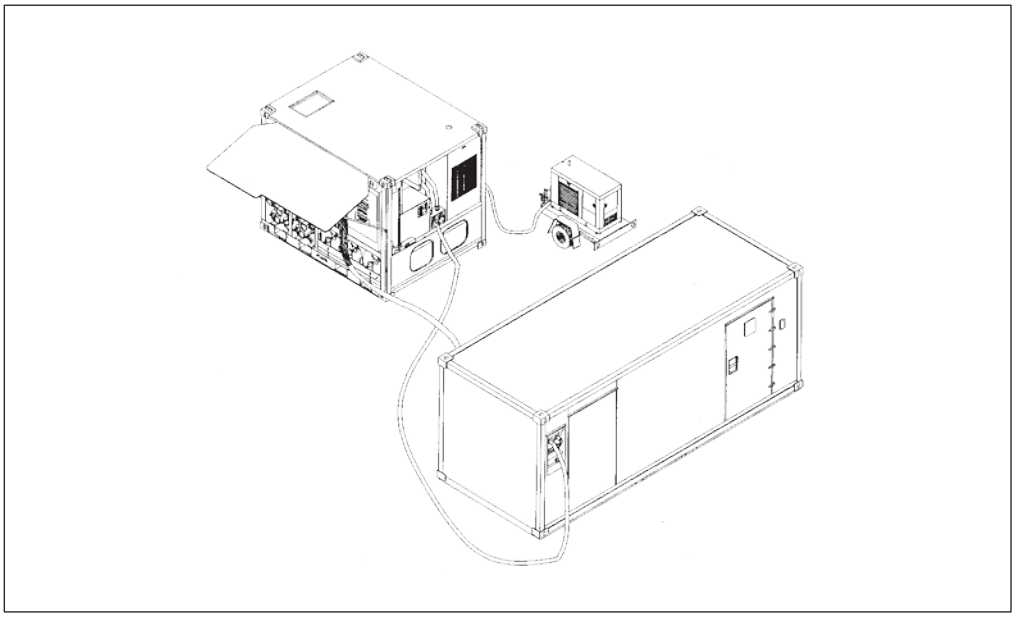


Figure 21-10. Fly Away Recompression Chamber (FARCC).

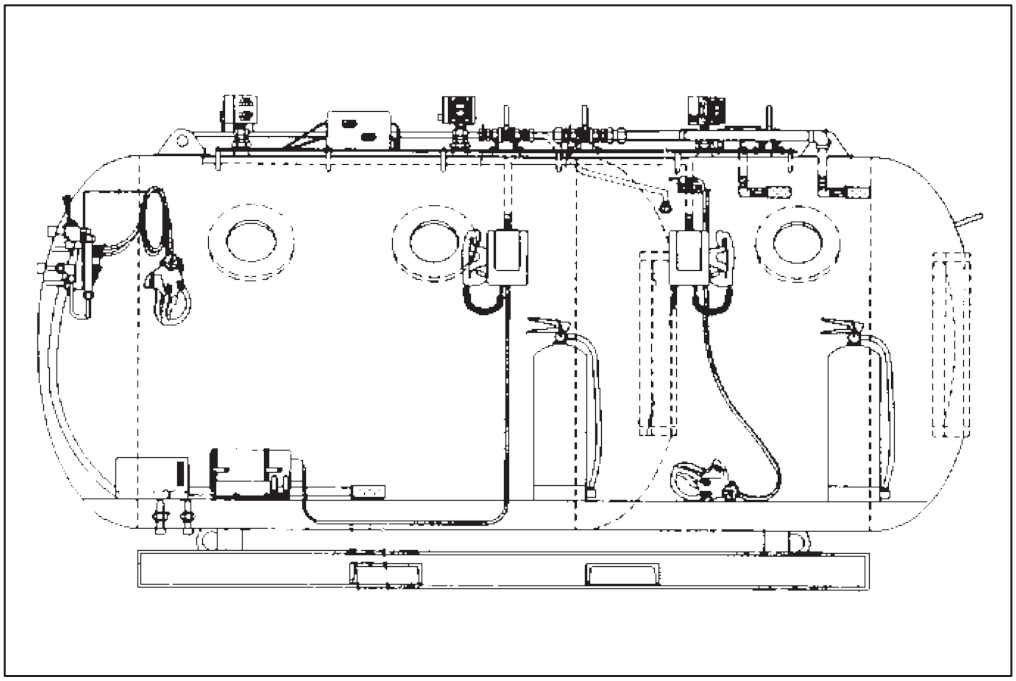


Figure 21-11. Fly Away Recompression Chamber.

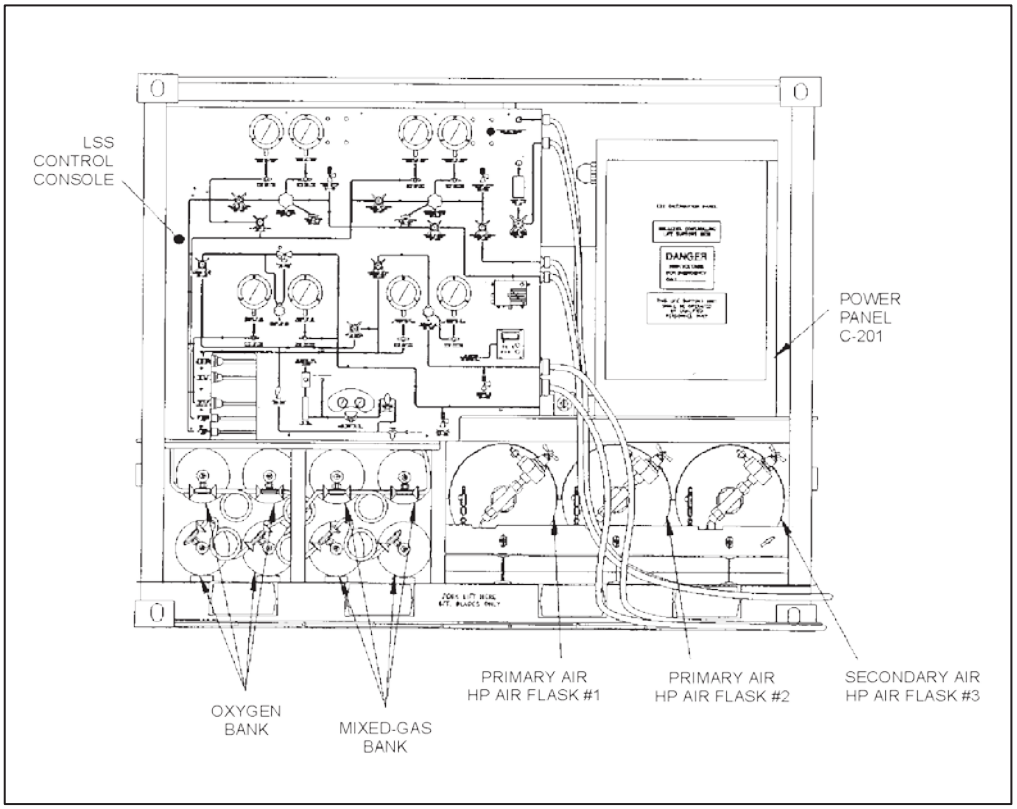


Figure 21-12. Fly Away Recompression Chamber Life Support Skid.

21-3 STATE OF READINESS

Since a recompression chamber is emergency equipment, it must be kept in a state of readiness. The chamber shall be well maintained and equipped with all neces- sary accessory equipment. A chamber is not to be used as a storage compartment.

The chamber and the air and oxygen supply systems shall be checked prior to each use with the Predive Checklist and in accordance with PMS instructions. All diving personnel shall be trained in the operation of the recompression chamber equipment and should be able to perform any task required during treatment.

21-4 GAS SUPPLY

A recompression chamber system must have a primary and a secondary air supply system that satisfies Table 21-3. The purpose of this requirement is to ensure the recompression chamber system, at a minimum, is capable of conducting a Treatment Table 6A (TT6A).

21-4.1 Capacity. Either system may consist of air banks and/or a suitable compressor. The primary air supply system must haKe sufficient air to pressurize the inner locG once to 165 fsw and the outer lock twice to 165 fsw and ventilate the chamber as specified in Table 21-3.

- Primary System Capacity:
  $C_p = (5 \times V_{il}) + (10 \times V_{ol}) + RV$

Where:
C_p = minimum capacity of primary system in SCF
V_{il} = volume of inner lock
V_{ol} = volume of outer lock
5 = atmospheres equivalent to 165 fsw
10 = twice the atmospheres equivalent to 165 fsw
RV = required ventilation. See paragraph 21-5.4 for Category A and B ventilation requirements. Not used for Category C, D, and E.

The secondary air supply system must haKe sufficient air to pressurize the inner and outer locGs once to 165 fsw plus Kentilate the chamber as specified in Table 21-3.

- Secondary System Requirement:
  $C_s = (5 \times V_{il}) + (5 \times V_{ol}) + RV$
  Where:
  C_s = minimum capacity of secondary system in SCF
  V_{il} = volume of inner lock
  V_{ol} = volume of outer lock
  5 = atmospheres equivalent to 165 fsw
  RV= required ventilation. For Category A, B, and C, use 4,PP4 for ventilation rate of 70.4 scfm for one hour. For Category D and E, calculate air or NITROX required for two patients and one tender to breathe BIBS (when not on O_2) during one TT6A with maximum extensions.

Table 21-3. *Recompression Chamber Air Supply Requirements.*

Recompression Chamber Configuration	Primary Air Requirement	Secondary Air Requirement
CATEGORY A: No BIBS overboard dump No CO_2 scrubber No air BIBS No O_2 and CO_2 monitor	Sufficient air to press the IL once and the OL twice to 135 fsw and vent during one TT6A for one tender and two patients with maximum extensions.	Sufficient air to press the IL and OL once to 135 fsw and vent for one hour at -0.4scfm.
CATEGORY B: BIBS overboard dump No CO_2 scrubber No air BIBS O_2 and CO_2 monitors	Sufficient air to press the IL once and the OL twice to 135 fsw and vent for CO_2 during one TT6A for one tender and two patients with maximum extensions.	Sufficient air to press the IL and OL once to 135 fsw and vent for one hour at -0.4scfm.
CATEGORY C: BIBS overboard dump CO_2 scrubber No air BIBS O_2 and CO_2 monitors	Sufficient air to press the IL once and the OL twice to 135 fsw.	Sufficient air to press the IL and OL once to 135 fsw and vent for one hour at -0.4scfm.
CATEGORY D: BIBS overboard dump CO_2 scrubber Air BIBS O_2 and CO_2 monitor	Sufficient air to press the IL once and the OL twice to 135 fsw. (For TRCS, sufficient air to power CO_2 scrubbers must be included)	Sufficient air to press the IL and OL once to 135 fsw and enough air for one tender and two patients (when not on O_2) to breathe air BIBS during one TT6A with maximum extensions
CATEGORY E: BIBS overboard dump CO_2 scrubber O_2 and CO_2 monitor Spare CO_2 scrubber Secondary power supply NITROX BIBS No Air BIBS	Sufficient air to press the IL once and the OL twice to 135 fsw.	Sufficient air to press the IL and OL once to 135 fsw and enough air/NITROX for one tender and two patients (when not on O_2) to breathe air/NITROX BIBS during one TT6A with maximum extensions.
Notes: Additional air source per .SOB will be required for TT4, - or 8. For chambers used to conduct Sur "D" sufficient air is re4uired to conduct a TT6A in addition to any planned Sur "D."		

21-5 OPERATION

21-5.1 Predive Checklist. To ensure each item is operational and ready for use, perform the equipment checks listed in the Recompression Chamber Predive Checklist, Figure 21-13.

21-5.2 Safety Precautions.

- Do not use oil on any oxygen fitting, air fitting, or piece of equipment.
- Do not allow oxygen supply tanks to be depleted below 100 psig.
- Ensure dogs are in good operating condition and seals are tight.
- Do not leave doors dogged (if applicable) after pressurization.
- Do not allow open flames, smoking materials, or any flammables to be carried into the chamber.
- Do not permit electrical appliances to be used in the chamber unless listed in the Authorization for Military Use (AMU).
- Do not perform unauthorized repairs or modifications on the chamber support systems.
- Do not permit products in the chamber that may contaminate or off-gas into the chamber atmosphere.

21-5.3 General Operating Procedures.

- Ensure completion of Predive Checklist.
- Diver and tender enter the chamber together.
- Diver sits in an uncramped position.
- Tender closes and dogs (if so equipped) the inner lock door.
- Pressurize the chamber, at the rate and to the depth specified in the appropriate decompression or recompression table.
- As soon as a seal is obtained or upon reaching depth, tender releases the dogs (if so equipped).
- Ventilate chamber according to specified rates and energize CO_2 scrubber and chamber conditioning system.
- Ensure proper decompression of all personnel.
- Ensure completion of Postdive Checklist.

RECOMPRESSION CHAMBER PREDIVE CHECKLIST	
Equipment	**Initials**
Chamber	
System certified	
Cleared of all extraneous equipment	
Clear of noxious odors	
Doors and seals undamaged, seals lubricated	
Pressure gauges calibrated/compared	
Air Supply System	
Primary and secondary air supply adequate	
One-valve supply: Valve closed	
Two-valve supply: Outside valve open, inside valve closed, if applicable	
Equalization valve closed, if applicable	
Supply regulator set at 250 psig or other appropriate pressure	
Fittings tight, filters clean, compressors fueled	
Exhaust System	
One-valve exhaust: Valve closed and calibrated for ventilation	
Two-valve exhaust: Outside valve open, inside valve closed, if applicable	
Oxygen Supply System	
Cylinders full, marked as BREATHING OXYGEN, cylinder valves open	
Replacement cylinders on hand	
Built in breathing system (BIBS) masks installed and tested	
Supply regulator set in accordance with OPs	
Fittings tight, gauges calibrated	
Oxygen manifold valves closed	
BIBS dump functioning	

Figure 21-13. Recompression Chamber Predive Checklist (sheet 1 of 2).

RECOMPRESSION CHAMBER PREDIVE CHECKLIST	
Equipment	**Initials**
Electrical System	
Lights	
Carbon dioxide analyzer calibrated	
Oxygen analyzer calibrated	
Temperature indicator calibrated	
Carbon dioxide scrubber operational	
Chamber conditioning unit operational	
Direct Current (DC) power supply	
Ground Fault Interrupter (GFI)	
Communication System	
Primary system tested	
Secondary system tested	
Fire Prevention System	
Tank pressurized for chambers with installed fire suppression systems	
Combustible material in metal enclosure	
Fire-retardant clothing worn by all chamber occupants	
Fire-resistant mattresses and blankets in chamber	
Means of extinguishing a fire	
Miscellaneous	
Inside Chamber:	
CO_2-absorbent canister with fresh absorbent installed	
Urinal	
Primary medical kit	
Ear protection sound attenuators/ear protectors (1 set per person) Must have a 1/13" hole drilled to allow for e4ualization.	
Outside Chamber:	
Heater/chiller unit	
Stopwatches for recompression treatment time, decompression time, personnel leaving chamber time, and cumulative time	
Fresh CO_2 scrubber canister	
U.S. Navy Diving Manual, Volume 5	
Ventilation bill	
Chamber log	
Operating Procedures (OPs) and Emergency Procedures (EPs)	
Secondary medical kit	
Bedpan (to be locked in as required)	

Figure 21-13. Recompression Chamber Predive Checklist (sheet 2 of 2).

21-5.3.1 **Tender Change-Out.** During extensive treatments, medical personnel may prefer to lock-in to examine the patient and then lock-out, rather than remain inside throughout the treatment. Inside tenders may tire and need relief.

21-5.3.2 **Lock-In Operations.** Personnel entering the chamber go into the outer lock and close and dog the door (if applicable). The outer lock should be pressurized at a rate controlled by their ability to equalize, but not to exceed 75 feet per minute. The outside tender shall record the time pressurization begins to determine the decompression schedule for the occupants when they are ready to leave the chamber. When the pressure levels in the outer and inner locks are equal, the inside door (which was undogged at the beginning of the treatment) should open.

21-5.3.3 **Lock-Out Operations.** To exit the chamber, the personnel again enter the outer lock and the inside tender closes and dogs the inner door (if so equipped). When ready to ascend, the Diving Supervisor is notified and the required decompression schedule is selected and executed. Constant communications are maintained with the inside tender to ensure that a seal has been made on the inner door. Outer lock depth is controlled throughout decompression by the outside tender.

21-5.3.4 **Gag Valves.** The actuating lever of the chamber gag valves shall be maintained in the open position at all times, during both normal chamber operations and when the chamber is secured. The gag valves must be closed only in the event of relief valve failure during chamber operation. Valves are to be lock-wired in the open position with light wire that can be easily broken when required. A WARNING plate, bearing the inscription shown below, shall be affixed to the chamber in the vicinity of each gag valve and shall be readily viewable by operating personnel. The WARNING plates shall measure approximately 4 inches by 6 inches and read as follows:

WARNING
The gag valve must remain open at all times.
Close only if relief valve fails.

21-5.4 Ventilation. The basic rules for ventilation are presented below. These rules permit rapid computation of the cubic feet of air per minute (acfm) required under different conditions as measured at chamber pressure (the rules are designed to ensure that the effective concentration of carbon dioxide will not exceed 1.5 percent (11.4 mmHg) and that when oxygen is being used, the percentage of oxygen in the chamber will not exceed 25 percent).

1. When air is breathed, provide 2 cubic feet per minute (acfm) for each diver at rest and 4 cubic feet per minute (acfm) for each diver who is not at rest (i.e., a tender actively taking care of a patient).

2. When oxygen is breathed from the built-in breathing system (BIBS), provide 12.5 acfm for a diver at rest and 25 acfm for a diver who is not at rest. When these ventilation rates are used, no additional ventilation is required for personnel breathing air. These ventilation rates apply only to the number of people breathing oxygen and are used only when no BIBS dump system is installed.

3. If ventilation must be interrupted for any reason, the time should not exceed 5 minutes in any 30-minute period. When ventilation is resumed, twice the volume of ventilation should be used for the time of interruption and then the basic ventilation rate should be used again.

4. If a BIBS dump system or a closed circuit BIBS is used for oxygen breathing, the ventilation rate for air breathing may be used.

5. If portable or installed oxygen and carbon dioxide monitoring systems are available, ventilation may be adjusted to maintain the oxygen level below 25 percent by volume and the carbon dioxide level below 1.5 percent surface equivalent (sev).

21-5.4.1 **Chamber Ventilation Bill.** Knowing how much air must be used does not solve the ventilation problem unless there is some way to determine the volume of air actually being used for ventilation. The standard procedure is to open the exhaust valve a given number of turns (or fraction of a turn), which will provide a certain number of cubic feet of ventilation per minute at a specific chamber depth, and to use the supply valve to maintain a constant chamber depth during the ventilation period. Determination of valve settings required for different amounts of ventilation at different depths is accomplished as follows.

WARNING **This procedure is to be performed with an unmanned chamber to avoid exposing occupants to unnecessary risks.**

1. Mark the valve handle position so that it is possible to determine accurately the number of turns and fractions of turns.

2. Check the basic ventilation rules above against probable situations to determine the rates of ventilation at various depths (chamber pressure) that may be needed. If the air supply is ample, determination of ventilation rates for a few depths (30, 60, 100, and 165 feet) may be sufficient. It will be convenient to know the valve settings for rates such as 6, 12.5, 25, or 37.5 cubic feet per minute (acfm).

3. Determine the necessary valve settings for the selected flows and depths by using a stopwatch and the chamber as a measuring vessel.
4. Calculate how long it will take to change the chamber pressure by 10 feet if the exhaust valve lets air escape at the desired rate close to the depth in question. Use the following formula.

$$T = \frac{V \times 60 \times \Delta P}{R \times (D + 33)}$$

Where:
T = time in seconds for chamber pressure to change 10 feet
V = internal volume of chamber (or of lock being used for test) in cubic feet (cf)
R = rate of ventilation desired, in cubic feet per minute as measured at chamber pressure (acfm)
ΔP = change in chamber pressure in fsw
D = depth in fsw (gauge)

Example: Determine how long it will take the pressure to drop from 170 to 160 feet in a 425-cubic-foot chamber if the exhaust valve is releasing 6 cubic feet of air per minute (measured at chamber pressure of 165 feet).

1. List values from example:
   T = unknown
   V = 425 cf
   R = 6 acfm
   ΔP = 10 fsw
   D = 165 fsw

2. Substitute values and solve to find how long it will take for the pressure to drop:

$$T = \frac{425 \times 60 \times 10}{6(165 + 33)}$$
$$= 215 \text{ seconds}$$

$$T = \frac{215 \text{ seconds}}{60 \text{ seconds / minute}}$$
$$= 3.6 \text{ minutes}$$

Increase the empty chamber pressure to 5 feet beyond the depth in question. Open the exhaust valve and determine how long it takes to come up 10 feet (for example, if checking for a depth of 165 fsw, take chamber pressure to 170 feet and clock the time needed to reach 160 feet). Open the valve to different settings until you can determine what setting will approximate the desired time. Record the setting. Calculate the times for other rates and depths and determine the settings for these times in the same way. Make a chart or table of valve setting versus ventilation rate and prepare a ventilation bill, using this information and the ventilation rules.

21-5.4.2 **Notes on Chamber Ventilation.**

- The basic ventilation rules are not intended to limit ventilation. Generally, if air is reasonably plentiful, more air than specified should be used for comfort. This increase is desirable because it also further lowers the concentrations of carbon dioxide and oxygen.

- There is seldom any danger of having too little oxygen in the chamber. Even with no ventilation and a high carbon dioxide level, the oxygen present would be ample for long periods of time.

- These rules assume that there is good circulation of air in the chamber during ventilation. If circulation is poor, the rules may be inadequate. Locating the inlet near one end of the chamber and the outlet near the other end improves ventilation.

- Coming up to the next stop reduces the standard cubic feet of gas in the chamber and proportionally reduces the quantity (scfm) of air required for ventilation.

- Continuous ventilation is the most efficient method of ventilation in terms of the amount of air required. However, it has the disadvantage of exposing the divers in the chamber to continuous noise. At the very high ventilation rates required for oxygen breathing, this noise can reach the level at which hearing loss becomes a hazard to the divers in the chamber. If high sound levels do occur, especially during exceptionally high ventilation rates, the chamber occupants must wear ear protectors (available as a stock item). A small hole should be drilled into the central cavity of the protector so that they do not pro- duce a seal which can cause ear squeeze.

- The size of the chamber does not influence the rate (acfm) of air required for ventilation.

- Increasing depth increases the actual mass of air required for ventilation; but when the amount of air is expressed in volumes as measured at chamber pres- sure, increasing depth does not change the number of actual cubic feet (acfm) required.

- If high-pressure air banks are being used for the chamber supply, pressure changes in the cylinders can be used to check the amount of ventilation being provided.

21-6 CHAMBER MAINTENANCE

21-6.1 Postdive Checklist. To ensure equipment receives proper postdive maintenance and is returned to operational readiness, perform the equipment checks listed in the Recompression Chamber Postdive Checklist, Figure 21-14.

21-6.2 Scheduled Maintenance. Every USN recompression chamber shall adhere to PMS requirements and shall be pressure tested when initially installed, at 2-year intervals thereafter, and after a major overhaul or repair. This test shall adhere to PMS requirements and shall be conducted in accordance with Figure 21-15. The completed test form shall be retained until retest is conducted. For a permanently installed chamber, removing and reinstalling constitutes a major overhaul and requires a pressure test. For portable chambers such as the TRCS, SNDLRCS, and FARCC, follow operating procedures after moving the chamber prior to manned use.

RECOMPRESSION CHAMBER POSTDIVE CHECKLIST	
Equipment	**Initials**
Air Supply	
All valves closed	
Air banks recharged, gauged, and pressure recorded	
Compressors fueled and maintained per technical manual/PMS requirements	
View Ports and Doors	
View-ports checked for damage; replaced as necessary	
Door seals checked, replaced as necessary	
Door seals lightly lubricated with approved lubricant	
Door dogs and dogging mechanism checked for proper operation and shaft seals for tightness	
Chamber	
Inside wiped clean with Nonionic Detergent (NID) and warm fresh water	
All unnecessary support items removed from chamber	
Blankets cleaned and replaced	
All flammable material in chamber encased in fire-resistant containers	
Primary medical kit restocked as re4uired	
Chamber aired out	
Outer door closed	
CO_2 canister packed	
Deckplates lifted, area below deckplates cleaned, deckplates reinstalled	
Support Items	
Stopwatches checked and reset	
U.S. Navy Diving Manual, Operating Procedures (OPs), Emergency Procedures (E.s), ventilation bill and pencil available at control desk	
Secondary medical kit restocked as required and stowed	
Clothing cleaned and stowed	
All entries made in chamber log book	
Chamber log book stowed	

Figure 21-14. Recompression Chamber Postdive Checklist (sheet 1 of 2).

RECOMPRESSION CHAMBER POSTDIVE CHECKLIST	
Equipment	**Initials**
Oxygen Supply	
BIBS mask removed, cleaned per current PMS procedures, reinstalled	
All valves closed	
System bled	
Breathing oxygen cylinders fully pressurized	
Spare cylinders available	
System free of contamination	
Exhaust System	
One-valve exhaust: valves closed	
Two-valve exhaust: inside valves closed	
Two-valve exhaust: outside valves opened	
Electrical	
All circuits checked	
Light bulbs replaced as necessary	
Pressure-proof housing of lights checked	
All power OFF	
Wiring checked for fraying	

Figure 21-14. Recompression Chamber Postdive Checklist (sheet 2 of 2).

Chamber relief valves shall be tested in accordance with the Planned Maintenance System to verify setting. Each tested relief valve shall be tagged to indicate the valve set pressure, date of test, and testing activity. After every use or once a month, whichever comes first, the chamber shall receive routine maintenance in accordance with the Postdive Checklist. At this time, minor repairs shall be made and used supplies shall be restocked.

21-6.2.1 **Inspections.** At the discretion of the activity, but at least once a year, the chamber shall be inspected, both inside and outside. Any deposits of grease, dust, or other dirt shall be removed and, on steel chambers, the affected areas repainted.

21-6.2.2 **Corrosion.** Corrosion is removed best by hand or by using a scraper, being careful not to gouge or otherwise damage the base metal. The corroded area and a small area around it should then be cleaned to remove any remaining paint and/or corrosion.

21.6.2.3 **Painting Steel Chambers.** Steel Chambers shall be painted utilizing original paint specifications and in accordance with approved NAVSEA or NAVFAC procedures. The following paints shall be utilized on NAVSEA carbon steel chambers:

PRESSURE TEST FOR USN RECOMPRESSION CHAMBERS

NOTE
All U.S. Navy Standard recompression chambers are restricted to a maximum operating pressure of 100 psig, regardless of design pressure rating.

A pressure test shall be conducted on every USN recompression chamber:

- When initially installed
- After repairs/overhaul
- At two-year intervals at a given location

Performance of the test and the test results are recorded on a standard U.S. Navy Recompression Chamber Air Pressure and Leak Test form (Figure 21015).

The test is conducted as follows:

1. Pressurize the innermost lock to 100 fsw (45 psig). Using soapy water or an e4uivalent solution, leak test all shell penetration fittings, view0ports, dog seals, door dogs (where applicable), valve connections, pipe joints, and shell weldments.

2. Mark all leaks. Depressurize the lock and adjust, repair, or replace components as necessary to eliminate leaks.

    a. View-Port Leaks. Remove the view-port gasket (replace if necessary), wipe clean.

CAUTION
Acrylic view-ports should not be lubricated or come in contact with any lubricant. Acrylic view-ports should not come in contact with any volatile detergent or leak detector (non-ionic detergent is to be used for leak test). When reinstalling view-port, take up retaining ring bolts until the gasket just compresses evenly about the view-port. Do not overcompress the gasket.

    b. Weldment Leaks. Contact appropriate NAVSEA technical authority for guidance on corrective action.

3. Repeat steps 1 and 2 until all the leaks have been eliminated.

4. Pressurize lock to 225 fsw (100 psig) and hold for 5 minutes.

WARNING
Do not exceed maximum pressure rating for the pressure vessel.

5. Depressurize the lock to 135 fsw (73.4 psig). Hold for 1 hour. If pressure drops below 145 fsw (35 psig), locate and mark leaks. Depressurize chamber and repair leaks in accordance with Step 2 above and repeat this procedure until final pressure is at least 145 fsw (65 psig).

6. Repeat Steps 1 through 5 leaving the inner door open and outer door closed. Leak test only those portions of the chamber not previously tested

Figure 21-15. Pressure Test for USN Recompression Chambers (sheet 1 of 3).

STANDARD U.S. NAVY RECOMPRESSION CHAMBER
AIR PRESSURE AND LEAK TEST
(Sheet 2 of 3)

Ship/Platform/Facility _____

Type of Chamber:

Recompression Chamber Facility - RCF5000
Recompression Chamber Facility - RCF3500
Transportable Recompression Chamber (TRC)
Fly-Away Recompression Chamber (FARCC)
Double-Lock Steel
Standard Navy Double Lock Recompression Chamber System (SNDLRCS)
Other* _____

NAME PLATE DATA

Manufacturer _____
Date of Manufacture _____
Contract/Drawing No. _____
Maximum Working Pressure _____
Date of Last Pressure Test _____
Test Conducted by _____
(Name/Rank)

1. Conduct visual inspection of chamber to determine if ready for test
   Chamber Satisfactory_____ Initials of Test Conductor _____
   Discrepancies from fully inoperative chamber equipment:
   _____
   _____

2 Close inner door lock. With outer lock door open pressure inner lock to 100 fsw (45 psig) and verify that the following components do not leak:
(Note: If chamber has medical lock, open inner door and close and secure outer door.)

Inner lock leak checks	Initials of Test Conductor
A. Shell penetrations and fittings	_____ Satisfactory
B. View Ports	_____ Satisfactory
C. Door Seals	_____ Satisfactory
D. Door Dog Shaft Seals	_____ Satisfactory
E. Valve Connections and Stems	_____ Satisfactory
F. Pipe Joints	_____ Satisfactory
G. Shell Welds	_____ Satisfactory

3. Increase inner lock pressure to 225 fsw (100 psig) and hold for 5 minutes.
   Record Test Pressure_____ Satisfactory_____
   (Note: Disregard small leaks at this pressure).

Figure 21-15. Pressure Test for USN Recompression Chambers (sheet 2 of 3).

STANDARD U.S. NAVY RECOMPRESSION CHAMBER
AIR PRESSURE AND LEAK TEST
(Sheet 3 of 3)

4. Depressurize lock slowly to 135 fsw (-3.4 psig). Secure all supply and exhaust valves and hold for one hour.
   Start Time_____ Pressure 135 fsw
   End Time_____ Pressure_____ fsw
   If pressure drops below 145 fsw (65 psig) locate and mark leaks. Depressurize, repair, and retest inner lock.
   Inner Lock Pressure drop test passed _____ (Satisfactory) Initials of Test Conductor

5. Depressurize inner lock and open inner lock door. Secure in open position. Close outer door and secure. (Note: If chamber has medical lock, close and secure inner door and open outer door.)

6. Repeat tests of sections 2, 3, and 4 above when set up in accordance with section 5. Leak test only those portions of the chamber not tested in sections 2, 3, and 4.

7. Outer Lock Checks — Initials of Test Conductor
   A. Shell penetrations and fittings _____ Satisfactory
   B. View Ports _____ Satisfactory
   C. Door Seals _____ Satisfactory
   D. Door Dog Shaft Seals _____ Satisfactory
   E. Valve Connections and Stems _____ Satisfactory
   F. Pipe Joints _____ Satisfactory
   G. Shell Welds _____ Satisfactory

8. Maximum Chamber Operating Pressure (100 psig) Test (5 minute hold)
   Satisfactory_____ Initials of Test Conductor

9. Inner and Outer Lock Chamber Drop Test
   Start Time_____ Pressure 165 fsw
   End Time_____ Pressure_____ fsw

Inner and outer lock pressure drop test passed satisfactorily _____ Initials of Test Conductor

10. All above tests have been satisfactorily completed.

_____
Test Director Date

_____
Diving Director Date

_____
Commanding Officer Date

Figure 21-15. Pressure Test for USN Recompression Chambers (sheet 3 of 3).

- Inside:
  - Prime coat NSN 8010-01-302-3608.
  - Finish coat white NSN 8010-01-302-3606.

- Outside:
  - Prime coat NSN 8010-01-302-3608.
  - Exterior coats gray NSN 8010-01-302-6838 or white NSN 8010-01- 302-3606.

For original paint specification on NAVFAC steel chambers refer to the Operation and Maintenance Support Information (OMSI) documentation delivered with the system.

21.6.2.4 **Recompression Chamber Paint Process Instruction.** Painting shall be kept to an absolute minimum. Only the coats prescribed above are to be applied. Naval Sea Systems Command will issue a Recompression Chamber Paint Process Instruction (NAV,EA-00C3-PI-001) on request.

21-6.2.5 **Stainless Steel Chambers.** Stainless steel chamber such as the TRCS and SNDLRCS do not require surfaces painted for corrosion resistance, only for cosmetic purposes. Naval Sea Systems Command will provide a Stainless Steel Recompression Chamber Paint Process Instruction on request.

21-6.2.6 **Fire Hazard Prevention.** The greatest single hazard in the use of a recompression chamber is from explosive fire. Fire may spread two to six times faster in a pressurized chamber than at atmospheric conditions because of the high partial pressure of oxygen in the chamber atmosphere. The following precautions shall be taken to minimize fire hazard:

- Maintain the chamber oxygen percentage as close to 21 percent as possible and never allow oxygen percentage to exceed 25 percent.

- Remove any fittings or equipment that do not conform with the standard requirements for the electrical system or that are made of flammable materials. Permit no wooden deck gratings, benches, or shelving in the chamber.

- Use only mattresses designed for hyperbaric chambers. Use Durett Product or submarine mattress (NSN 7210-00-275-5878 or 5874). Other mattresses may cause atmospheric contamination. Mattresses should be enclosed in flame- proof covers. Use 100% cotton sheets and pillow cases. Put no more bedding in a chamber than is necessary for the comfort of the patient. Never use blankets of wool or synthetic fibers because of the possibility of sparGs from static electricity.

- Clothing worn by chamber occupants shall be made of 100% cotton, or a flame resistant blend of cotton and polyester for chambers equipped with a fire extinguisher or fixed hand-held or fire suppression system. Diver swim trunks made of 65% polyester 35% cotton material are acceptable.

- Keep oil and volatile materials out of the chamber. If any have been used, ensure that the chamber is thoroughly ventilated before pressurization. Do not put oil on or in any fittings or high-pressure line. If oil is spilled in the chamber or soaked into any chamber surface or equipment, it must be completely removed. If lubricants are required, use only those approved and listed in *Naval Ships Technical Manual* (N,TM) NAV,EA ,9086-HW-,TM-000, ChapterP6P. Regularly inspect and clean air filters and accumulators in the air supply lines to protect against the introduction of oil or other vapors into the chamber. Permit no one to wear oily clothing into the chamber.

- Permit no one to carry smoking materials, matches, lighters or any flammable materials into a chamber. A WARNING sign should be posted outside the chamber. Example:

WARNING
Fire/Explosion Hazard. No matches, lighters, electrical appliances, or flammable materials permitted in chamber.

21-6.2.6.1 ***Fire Extinguishing.*** All recompression chambers must have a means of extinguishing a fire in the interior. Examples of fire protection include wetted towels, a bucket of water, fire extinguisher, hand-held hose system, or suppression/ deluge system. Refer to U.S. Navy General Specification for the Design, Construction, and Repair of Diving and Hyperbaric Equipment (TS500-AU-,PN-010) for specific requirements of fire protection systems. Only fire extinguishers listed on the NAVSEA Authorization for Military Use (AMU) are to be used.

21-7 DIVER CANDIDATE PRESSURE TEST

All U.S. Navy diver candidates shall be physically qualified in accordance with the *Manual of the Medical Department*, Art. 15-102. Candidates shall also pass a pressure test before they are eligible for diver training. This test may be conducted at any Navy certified recompression chamber, provided it is administered by qualified chamber personnel.

21-7.1 Candidate Requirements. The candidate must demonstrate the ability to equalize pressure in both ears to a depth of 60 fsw. The candidate shall have also passed the screening physical readiness test in accordance with MILPERSMAN 1220-100, Exhibit 1.

21-7.2 Procedure.

1. Candidates shall undergo a diving physical examination by a Navy Medical Officer in accordance with the *Manual of the Medical Department,* Art. 15-102, and be qualified to undergo the test.

2. The candidates and the tender enter the recompression chamber and are pressurized to 60 fsw on air, at a rate of 75 fpm or less as tolerated by the occupants.

3. If a candidate cannot complete the descent, the chamber is stopped and the candidate is placed in the outer lock for return to the surface.

4. Stay at 60 fsw for at least 10 minutes.

5. Ascend to the surface following standard air decompression procedures.

6. All candidates shall remain at the immediate chamber site for a minimum of 15 minutes and at the test facility for 1 hour. Candidates or tenders who must return to their command via air travel must proceed in accordance with Chapter 9, paragraph 9-14.

210-.2.1 **References.**

- *Navy Military Personnel Manual*, Art. 1220-100
- *Manual of the Medical Department*, Art. 15-102