

CHAPTER 21

Recompression Therapy

21-1 INTRODUCTION

21-1.1 Purpose. This chapter covers recompression therapy. Recompression therapy is indicated for treating omitted decompression, decompression sickness, and arterial gas embolism.

21-1.2 Scope. The procedures outlined in this chapter are to be performed only by personnel properly trained to use them. Because these procedures cover symptoms ranging from pain to life-threatening disorders, the degree of medical expertise necessary to carry out treatment properly will vary. Certain procedures, such as starting IV fluid lines and inserting chest tubes, require special training and should not be attempted by untrained individuals. Treatment tables can be executed without consulting a Diving Medical Officer (DMO), although a DMO should always be contacted at the earliest possible opportunity. Four treatment tables require special consideration:

- Treatment Table 4 is a long, arduous table that requires constant evaluation of the stricken diver.
- Treatment Table 7 and Treatment Table 8 allow prolonged treatments for severely ill patients based on the patient's condition throughout the treatment.
- Treatment Table 9 can only be prescribed by a Diving Medical Officer.

21-1.3 Diving Supervisor's Responsibilities. Experience has shown that symptoms of severe decompression sickness or arterial gas embolism may occur following seemingly normal dives. 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 help is not immediately on scene. Therefore, it is the Diving Supervisor's responsibility to ensure that every member of the diving team:

1. Is thoroughly familiar with all recompression procedures.
2. Knows the location of the nearest, certified recompression facility.
3. Knows how to contact a qualified Diving Medical Officer if one is not at the site.

21-1.4 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)
321 Bullfinch Road
Panama City, FL 32407-7015

Secondary:

Navy Diving Salvage and Training Center (NDSTC)
350 South Craig Rd.
Panama City, FL 32407-7015

Telephone numbers are listed in Volume 1, Appendix C.

21-1.5 Applicability of Recompression. 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 scuba diving, whether on air, nitrogen-oxygen, helium-oxygen, or 100 percent oxygen. For example, the treatment of arterial gas embolism has little to do with the gas being breathed at the time of the accident. Because all possible conditions cannot be anticipated, additional medical expertise should be sought in all cases of decompression sickness or arterial gas embolism that do not show substantial improvement on standard treatment tables. Treatment of decompression sickness during saturation 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 90 percent of the time when used as published. Deviation from these protocols shall be made only with the recommendation of a Diving Medical Officer.

21-1.6 Recompression Treatment for Non-Diving Disorders. In addition to individuals suffering from diving disorders, U.S. Navy recompression chambers are also permitted to conduct hyperbaric oxygen (HBO₂) 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 MED-21 shall be obtained before treatment begins (BUMEDINST 6320.38). 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 21-1 for conducting HBO₂ therapy are taken from the Undersea and Hyperbaric Medical Society's *Hyperbaric Oxygen (HBO₂) Therapy Committee Report—1996: 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 days of treatment.

Table 21-1. 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 <i>as recommended by the DMO</i>		5
Gas Gangrene (Clostridial Myonecrosis)	Treatment Table 5 <i>TID x 1 day then BID x 4–5 days</i>	5	10
Crush Injury, Compartment Syndrome, and other Acute Traumatic Ischemia	Treatment Table 9 <i>TID x 2 days BID x 2 days QD x 2 days</i>	3	12
Enhancements of Healing in Selected Wounds	Treatment Table 9 <i>QD or BID</i>	10	60
Necrotizing Soft-Tissue Infections (subcutaneous tissue, muscle, fascia)	Treatment Table 9 <i>BID initially, then QD</i>	5	30
Osteomyelitis (refractory)	Treatment Table 9 <i>QD</i>	20	60
Radiation Tissue Damage (osteoradinecrosis)	Treatment Table 9 <i>QD</i>	20	60
Skin Grafts and Flaps (compromised)	Treatment Table 9 <i>BID initially, then QD</i>	6	40
Thermal Burns	Treatment Table 9 <i>TID x 1 day, then BID</i>	5	45
QD = 1 time in 24 hours BID = 2 times in 24 hours TID = 3 times in 24 hours For further information, see <i>Hyperbaric Oxygen Therapy: A Committee Report, 1996 Revision</i> .			

21-1.7 Primary Objectives. Table 21-2 gives the basic rules that shall be followed for all recompression treatments. The three primary objectives of recompression treatment are to:

1. Compress gas bubbles to a small volume, thus relieving local pressure and restarting blood flow,
2. Allow sufficient time for bubble resorption, and

Table 21-2. 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. In the event of oxygen convulsion, remove the oxygen mask and keep the patient from self-harm. Do not force mouth open during 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 pain-only symptoms, 6 hours for serious symptoms.
12. Maintain accurate timekeeping and recording.
13. Maintain a well-stocked medical kit at hand.

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 mouth-to-mouth resuscitation immediately if breathing ceases.
3. Break rhythm during resuscitation.
4. Permit the use of 100 percent oxygen below 60 feet.
5. Fail to treat doubtful cases.
6. Allow personnel in the chamber to assume a cramped position that might interfere with complete blood circulation.

3. Increase blood oxygen content and thus oxygen delivery to injured tissues.

21-1.8

Guidance on Recompressed 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.

21-1.9 In-Water or Air Recompression. Recompression in a facility equipped for oxygen breathing is preferred. However, the procedures covered here also address situations where either no chamber is available or where only air is available at the recompression facility. In-water or air recompression treatments are used only when the delay in transporting the patient to a recompression facility having oxygen would cause greater harm.

21-2 PRESCRIBING AND MODIFYING TREATMENTS

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). DMOs shall have subspecialty codes of 16U0 or 16U1 (Undersea Medical Officer). Saturation Diving Medical Officers have an Additional Qualification Designator (AQD) of 6UD and Submarine Medical Officers an AQD of 6UM. Medical Officers who only complete the short diving medicine course at NDSTC do not receive DMO subspecialty codes, but are considered to have the same privileges as DMOs when treating diving accidents. Only those physicians cited in this paragraph may modify the treatment protocols as warranted by the patient's condition with concurrence of the Commanding Officer. Other physicians may assist and advise treatment and care of diving casualties but may not modify recompression procedures.

21-3 OMITTED DECOMPRESSION

Certain emergencies, such as uncontrolled ascents, an exhausted air supply, or bodily injury, may interrupt or prevent required decompression. If the diver shows symptoms of decompression sickness or arterial gas embolism, immediate treatment using the appropriate oxygen or air recompression treatment table is essential. Even if the diver shows no symptoms, omitted decompression must be addressed in some manner to avert later difficulty. Table 21-3 summarizes management of asymptomatic Omitted Decompression.

21-3.1 Planned and Unplanned Omitted Decompression. Omitted decompression may or may not be planned. Planned omitted decompression results when a condition develops at depth that will require the diver to surface before completing all of the decompression stops and when there is time to consider all available options, ready the recompression chamber, and alert all personnel as to the planned evolution. Equipment malfunctions, diver injury, or sudden severe storms are examples of these situations. In unplanned omitted decompression, the diver suddenly appears at the surface without warning or misses decompression for some unfore-

Table 21-3. Management of Asymptomatic Omitted Decompression.

Depth at Which Omission Began	Decompression Status	Eligible for Sur-D?	Surface Interval	Action	
				Chamber Available	No Chamber Available
20 fsw or shallower	No Decompression	N/A	N/A	Observe on surface for 1 hour.	
	Decompression Stops Required	Yes	Less than 5 minutes	Use Surface Decompression Tables.	Perform Chamber stops in water. (Note 1)
		No	Less than 1 minute	Return to depth of stop. Increase stop time 1 minute. Resume decompression.	
		No.	Greater than 1 minute.	Return to depth of stop. Multiply 20- and 10-foot stop times by 1.5. OR: Treatment Table 5 (1A) for surface interval less than 5 minutes. OR: Treatment Table 6 (2A) for surface interval greater than 5 minutes.	
Deeper than 20 fsw	No-Decompression	N/A	N/A	Observe on surface for 1 hour.	
	Decompression Stops Required	Yes	Less than 5 minutes.	Use Surface Decompression Tables	Perform chamber stops in water (Note 1)
	Decompression Stops Required (Less than 30 minutes missed)	No	Less than 5 minutes.	Treatment Table 5 (1A) (Note 2)	Descend to depth of first stop. Follow the schedule to 30 fsw.
		No	Greater than 5 minutes.	Treatment Table 6 (2A) (Note 2)	
Decompression Stops Required (Greater than 30 minutes)	No	Any	Treatment Table 6 (2A) (Note 2)	Multiply 30, 20, and 10 fsw stops by 1.5.	

Notes:

1. Sur-D Air only.
2. If a diver missed a stop deeper than 60 feet and oxygen is available, first compress to the depth of the first missed stop. Double this stop, then decompress to 60 feet using the appropriate decompression schedule doubling all stop times. Decompress from 60 feet on Treatment Table 5 or 6 as appropriate. If oxygen is unavailable, treat on a full Treatment Table 1A or 2A as appropriate.
3. Using a recompression chamber is strongly preferred over in-water recompression for returning a diver to pressure.

seen reason. In either instance, the Surface Decompression Tables may be used to remove the diver from the water, if the surfacing time occurs such that water stops are either not required or have already been completed. When the conditions that permit using the Surface Decompression Tables are not fulfilled, the diver's decompression will be compromised. Special care shall be taken to detect signs of decompression sickness. The diver must be returned to pressure as soon as possible.

21-3.2 Treating Omitted Decompression with Symptoms. If the diver develops symptoms of decompression sickness during the surface interval, treat in accordance with the procedures in paragraph 21-4 (no chamber available) or paragraph 21-5 (chamber available). If the diver has no symptoms of decompression sickness or

arterial gas embolism, make up the omitted decompression as described in this section.

- 21-3.3 Treating Omitted Decompression in Specific Operational Environments.** Refer to paragraph 17-10.6 for procedures for dealing with omitted decompression during MK 16 diving operations. Refer to paragraph 14-4.10 for procedures for dealing with omitted decompression during surface-supplied helium-oxygen diving operations.
- 21-3.4 Ascent from 20 Feet or Shallower (Shallow Surfacing) with Decompression Stops Required.** If the diver surfaced from 20 feet or shallower, feels well, and can be returned to stop depth within 1 minute, the diver may complete normal decompression stops. The decompression stop from which ascent occurred is lengthened by 1 minute. If the diver cannot be returned to the depth of the stop within 1 minute and the diver remains asymptomatic, return the diver to the stop from which the diver ascended. Multiply each decompression stop time missed by 1.5. Alternatively, if the surface interval is less than 5 minutes, the diver may be placed in a recompression chamber and treated on a Treatment Table 5 (or 1A if no oxygen is available). If the surface interval is greater than 5 minutes, the diver may be placed in a recompression chamber and treated on Treatment Table 6 (or 2A if no oxygen is available). The diver should be observed for 1 hour after surfacing and/or completing treatment.
- 21-3.5 Ascent from 20 Feet or Shallower with No Decompression Stops Required.** No recompression is required if the diver surfaces from 20 feet or shallower but was within no-decompression limits. The diver should be observed on the surface for 1 hour.
- 21-3.6 Ascent from Deeper than 20 Feet (Uncontrolled Ascent).** Any unexpected surfacing of the diver from depths in excess of 20 feet is considered an uncontrolled ascent. If the diver is within no-decompression limits and asymptomatic, he should be observed for at least 1 hour on the surface. Recompression is not necessary unless symptoms develop.
- 21-3.6.1 Asymptomatic Uncontrolled Ascent.** Asymptomatic divers who experience an uncontrolled ascent and who have missed decompression stops are treated by recompression based on the amount of decompression missed as follows:
- **Oxygen Available.** Immediately compress the diver to 60 feet in the recompression chamber. If less than 30 minutes of decompression (total ascent time from the tables) were missed, decompress from 60 feet on Treatment Table 5. If more than 30 minutes of decompression were missed, decompress from 60 feet on Treatment Table 6.
 - **Oxygen Not Available.** Compress the diver to 100 feet in the recompression chamber and treat on Table 1A if less than 30 minutes of decompression were missed; compress to 165 feet and treat on Table 2A if more than 30 minutes were missed.

21-3.6.2 **Development of Symptoms.** As long as the diver shows no ill effects, decompress in accordance with the treatment table. Consider any decompression sickness that develops during or after this procedure to be a recurrence. Try to keep all surface intervals as short as possible (5 minutes or less). If an asymptomatic diver who has an uncontrolled ascent from a decompression dive has more than a 5-minute surface interval, recompress to 60 feet on Treatment Table 6 or treat on Table 2A, even if the missed decompression time was less than 30 minutes.

21-3.6.3 **In-Water Procedure.** When no recompression facility is available, use the following in-water procedure to make up omitted decompression in asymptomatic divers for ascents from depths below 20 feet.

Recompress the diver in the water as soon as possible (preferably less than a 5-minute surface interval). Keep the diver at rest, provide a standby diver, and maintain good communication and depth control. Use the decompression schedule appropriate for the divers depth and bottom time. Follow the procedure below with 1 minute between stops:

1. Return the diver to the depth of the first stop.
2. Follow the schedule for stops 40-fsw and deeper.
3. Multiply the 30-, 20-, and 10-fsw stops by 1.5.

21-3.6.4 **Symptomatic Uncontrolled Ascent.** 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 uncontrolled ascent. If the diver surfaced from 60 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 depth where the symptoms are significantly improved, not to exceed 165 fsw, and begin Treatment Table 6A. Symptoms developing during the surface interval or during a period of observation on no-decompression dives are treated as described in paragraph 21-5 (reference Table 21-3). Consultation with a Diving Medical Officer should be made 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 site. Immediate transportation to a recompression facility is indicated; if this is impossible, the guidelines in paragraph 21-4 may be useful.

21-4 RECOMPRESSION TREATMENTS WHEN NO RECOMPRESSION CHAMBER IS AVAILABLE

The Diving Supervisor has two alternatives for recompression treatments 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 certified recompression chamber for treatment.

- 21-4.1 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 lying horizontally. Do not put the patient head-down. Additionally, the patient should be kept warm and monitored constantly for signs of 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 severe internal injuries.
- 21-4.1.1 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 treated as if the original symptom(s) were still present. Always ensure the patient is adequately hydrated. Give fluids by mouth if the patient is able to take them. Otherwise, intravenous fluids should be started before transport (paragraph 21-5.5.7). 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.
- 21-4.1.2 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. Any unnecessary altitude means an additional reduction in external pressure and possible additional symptom severity or complications. If available, always use aircraft that can be pressurized to one atmosphere.
- 21-4.1.3 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.
- 21-4.2 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 and there is no prospect of reaching a recompression facility within 12 hours. In an emergency, an uncertified chamber may be used if, in the opinion of the Diving Supervisor, 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, 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. To avoid hypothermia, it is important to consider water temperature when performing in-water recompression.
- 21-4.2.1 Surface Oxygen Treatment.** For less life-threatening cases, have the stricken diver begin breathing 100 percent oxygen immediately if it is available on site.

Continue breathing oxygen at the surface for 30 minutes before deciding 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. Continue breathing 100 percent oxygen as long as supplies last, up to a maximum time of 6 hours. If surface oxygen proves ineffective after 30 minutes, begin in-water recompression.

21-4.2.2 **In-Water Recompression Using Air.** In-water recompression using air is always less preferable than using oxygen.

1. Follow Treatment Table 1A as closely as possible.
 - a. Use either a full face mask or, preferably, a surface-supplied UBA. Never recompress a diver in the water using a scuba with a mouthpiece unless it is the only breathing source available.
 - b. Maintain constant communication.
2. 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.
3. If the depth is inadequate for full treatment according to Treatment Table 1A:
 - a. Recompress the patient to the maximum available depth.
 - b. Remain at maximum depth for 30 minutes.
 - c. Decompress according to Treatment Table 1A. Do not use stops shorter than those of Treatment Table 1A.

21-4.2.3 **In-Water Recompression Using Oxygen.** If a 100 percent oxygen rebreather is available and individuals at the dive site are trained in its use, the following in-water recompression procedure may be used instead of Table 1A:

1. Put the stricken diver on the UBA and have the diver purge the apparatus at least three times with oxygen.
2. Descend to a depth of 30 feet with a standby diver.
3. Remain at 30 feet, at rest, for 60 minutes for Type I symptoms and 90 minutes for Type II symptoms. Ascend to 20 feet even if symptoms are still present.
4. Decompress to the surface by taking 60-minute stops at 20 feet and 10 feet.
5. After surfacing, continue breathing 100 percent oxygen for an additional 3 hours.
6. If symptoms persist or recur on the surface, arrange for transport to a recompression facility regardless of the delay.

- 21-4.2.4 **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.
- 21-4.3 **Symptoms During Decompression (No Chamber Available).** Development of decompression sickness in the water is uncommon when U.S. Navy decompression procedures are followed, but when it does occur it is likely to be at shallow stops. The symptoms are usually Type I and respond quickly to minimal recompression. Follow the flowchart in Figure 21-3 for proper management. Only recompress an additional 10 feet if no significant improvement was noted after the first 10-fsw recompression. Remain at treatment depth 30 minutes in addition to any required decompression stop time. If no decompression time is required at the treatment depth, remain there for 30 minutes. Shift diver to 100 percent oxygen at depths of 30 feet and shallower if possible. If symptoms persist after surfacing, have the diver breathe 100 percent oxygen while arranging evacuation to a recompression facility. Do not conduct in-water recompression for residual symptoms after surfacing. Once a recompression facility is reached, any symptoms are treated as a recurrence of Type II symptoms.

21-5 RECOMPRESSION TREATMENTS WHEN CHAMBER IS AVAILABLE

Oxygen Treatment Tables are more effective and, therefore, preferable over Air Treatment Tables. Treatment Table 4 can be used with or without oxygen but should always be used with oxygen if it is available.

- 21-5.1 **Symptoms During Decompression and Surface Decompression (Recompression Chamber Available).** If symptoms of decompression sickness occur in the water during decompression, follow the flowchart in Figure 21-3. After completing recompression treatment, observe the diver for at least 6 hours. If any symptoms recur, treat as a recurrence of Type II symptoms. As an option, the on-site Diving Supervisor may elect not to recompress the diver 10 feet in the water, but to remove the diver from the water when decompression risks are acceptable and treat him in the chamber. When this is done, the surface interval should be 5 minutes or less, with the diver always treated as having Type II symptoms.
- 21-5.1.1 **Treatment During Surface-Supplied HEO₂ and MK 16 Operations.** Treatment of decompression sickness arising in the water in specific operational environments is presented in Volume 3 for surface-supplied helium-oxygen dives and Volume 4 for MK 16 diving operations.
- 21-5.1.2 **Treatment of Symptoms During Sur-D Surface Interval.** If surface decompression procedures are used, symptoms of decompression sickness may occur during the surface interval. Because neurological symptoms cannot be ruled out during this short period, the symptomatic diver is treated as having Type II symptoms, even if the only complaint is pain.

21-5.1.3 **Treating for Exceeded Sur-D Surface Interval.** If the prescribed surface interval is exceeded but the diver remains asymptomatic, the diver is treated with Treatment Table 5, or Treatment Table 1A if no oxygen is available. If the diver becomes symptomatic, the diver is treated as if Type II symptoms were present. Any symptoms occurring during the chamber stops of Surface Decompression Tables are treated as recurrences in accordance with Figure 21-6.

21-5.2 **Recompression Treatments When Oxygen Is Not Available.** If no oxygen is available, select the appropriate Air Treatment Table in accordance with Figure 21-10, Figure 21-14, Figure 21-15, and Figure 21-16.

Use 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 Table 2A. Table 3 is used for treatment of serious symptoms where oxygen cannot be used. Use 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 Table 4.

21-5.2.1 **Descent/Ascent Rates for Air Treatment Tables.** The Air Treatment Tables (1A, 2A, 3, and 4 using air) are used when no oxygen is available. They are not as effective as the Oxygen Treatment Tables. The descent rate is 20 feet per minute; the ascent rate is not to exceed 1 foot per minute.

21-5.3 **Treatment at Altitude.** Before starting a 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.

21-5.4 **Recompression Treatments When Oxygen Is Available.** Use Oxygen Treatment Tables 5, 6, 6A, 4, or 7, according to the flowcharts in Figure 21-4, Figure 21-5, and Figure 21-6. The descent rate is 20 feet per minute. Upon reaching treatment depth not to exceed 60 fsw, place the patient on oxygen. For depth deeper than 60 fsw, use treatment gas if available. Additional guidelines for each treatment table are given below.

21-5.4.1 **Treatment Table 5.** Treatment Table 5 may be used for the following:

- Type I (except for cutis-marmorata) symptoms when a complete neurological examination has revealed no abnormality
- Asymptomatic omitted decompression of shallow surfacing (20 fsw or less)
- Asymptomatic omitted decompression of rapid ascent (from deeper than 20 fsw) if the missed decompression is less than 30 minutes
- Asymptomatic divers who have exceeded surface interval limits following a Sur-D dive
- Treatment of resolved symptoms following in-water recompression
- Follow-up treatments for residual symptoms

- Carbon monoxide poisoning
- Gas gangrene

21-5.4.1.1 **Performance of Neurological Exam at 60 fsw.** After arrival at 60 fsw a neurological exam shall be performed (see [Appendix 5A](#)) to ensure that no overt neurological symptoms (e.g., weakness, numbness, incoordination) are present. If any abnormalities are found, the stricken diver should be treated using Treatment Table 6.

21-5.4.1.2 **Extending Oxygen Breathing Periods on Treatment Table 5.** Treatment Table 5 may be extended by two oxygen breathing periods at 30 fsw. Air breaks are not required prior to an extension, between extensions, or prior to surfacing. In other words, the Diving Supervisor may have the patient breathe oxygen continuously for 60 minutes at 30 fsw and travel to the surface while breathing oxygen. If the Diving Supervisor elects to extend this treatment table, the tender does not require additional oxygen breathing than currently prescribed.

21-5.4.1.3 **When Use of Treatment Table 6 is Mandatory.** Treatment Table 6 is mandatory if:

- Type I pain is severe and immediate recompression must be instituted before a neurological examination can be performed, or
- A complete neurological examination cannot be performed, or
- Any neurological symptom is present.

These rules apply no matter how rapidly or completely the symptoms resolve once recompression begins.

21-5.4.1.4 **Complete Relief after 10 Minutes.** If complete relief of Type I symptoms is not obtained within 10 minutes at 60 feet, Table 6 is required.

21-5.4.1.5 **Musculoskeletal Pain Due to Orthopedic Injury.** 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, Treatment Table 5 may be completed. If no Diving Medical Officer is on site, Treatment Table 6 shall be used.

NOTE **Once recompression to 60 feet is done, Treatment Table 5 shall be used even if it was decided symptoms were probably not decompression sickness. Direct ascent to the surface is done only in emergencies.**

21-5.4.2 **Treatment Table 6.** Treatment Table 6 is used for the following:

- Type I symptoms where relief is not complete within 10 minutes at 60 feet or where a neurological exam is not complete

- Type II symptoms
- Cutis marmorata
- Severe carbon monoxide poisoning, cyanide poisoning, or smoke inhalation
- Arterial gas embolism
- Symptomatic uncontrolled ascent
- Asymptomatic divers with omitted decompression greater than 30 minutes
- Treatment of unresolved symptoms following in-water treatment
- Recurrence of symptoms shallower than 60 fsw

21-5.4.2.1 **Treating Arterial Gas Embolism.** Arterial gas embolism is treated by initial compression to 60 fsw. If symptoms are improved within the first oxygen breathing period, then treatment is continued using Treatment Table 6. Treatment Table 6 may be extended for two oxygen breathing periods at 60 fsw (20 minutes on oxygen, then 5 minutes on air, then 20 minutes on oxygen) and two oxygen breathing periods at 30 fsw (15 minutes on air, then 60 minutes on oxygen, then 15 minutes on air, then 60 minutes on oxygen). If there has been more than one extension, the tenders' breathing period is extended 60 minutes at 30 feet.

21-5.4.3 **Treatment Table 6A.** Arterial gas embolism or severe decompression symptoms are treated by initial compression to 60 fsw. If symptoms improve, complete Treatment Table 6. If symptoms are unchanged or worsen, assess the patient upon descent and compress to depth of relief (significant improvement), not to exceed 165 fsw. Once at the depth of relief, begin treatment gas (N₂O₂, HeO₂) if available. Stay there for 30 minutes. A breathing period of 25 minutes on treatment gas, interrupted by 5 minutes of air, is recommended at depth to simplify time keeping. The patient may remain on treatment gas during ascent from treatment depth to 60 fsw since the PO₂ will continually decrease during ascent. Decompress to 60 fsw at a travel rate not to exceed 3 ft./min. Upon arrival at 60 fsw, complete Treatment Table 6. Consult with a Diving Medical Officer at the earliest opportunity. The Diving Medical Officer may recommend a Treatment Table 4. Treatment Table 6A may be extended for two oxygen breathing periods at 60 fsw and two oxygen breathing periods at 30 fsw. If deterioration is noted during ascent to 60 feet, treat as a recurrence of symptoms (Figure 21-6).

21-5.4.4 **Treatment Table 4.** If a shift from Treatment Table 6A to Treatment Table 4 is contemplated, a Diving Medical Officer shall be consulted before the shift is made. Treatment Table 4 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.

21-5.4.4.1 **Recurrence of Symptoms.** If deterioration is noted during ascent to 60 feet, treat as a recurrence of symptoms (Figure 21-6).

- 21-5.4.4.2 **Oxygen Breathing Periods.** 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 (paragraph 21-5.5.6). 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.
- 21-5.4.5 **Treatment Table 7.** Treatment Table 7 is considered an heroic measure for treating non-responding severe gas embolism or life-threatening decompression sickness. 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.
- 21-5.4.5.1 **Considerations.** A Diving Medical Officer shall be consulted before shifting to a Treatment Table 7 and careful consideration shall be given to life support capability (paragraph 21-5.6). In addition, it must be realized that the recompression facility will be committed for 48 hours or more.
- 21-5.4.5.2 **Indications.** Treatment Table 7 is an extension at 60 feet of Treatment Tables 6, 6A, or 4 (or any other nonstandard treatment table). This means that considerable treatment has already been administered. Treatment Table 7 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.
- 21-5.4.5.3 **Consultation with NEDU or NDSTC.** Because it is difficult to judge whether a particular patient's condition warrants Treatment Table 7, additional consultation from either NEDU or NDSTC must be obtained. Telephone numbers are listed in Appendix 1C.
- 21-5.4.5.4 **Time at Depth.** 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 below 60 feet, at least 12 hours must be spent at 60 feet and then 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.

- 21-5.4.5.5 **Decompression.** When using Treatment Table 7, tenders breathe chamber atmosphere. Chamber oxygen should be kept above 19 percent (paragraph 21-5.6.3) and carbon dioxide below 1.5 percent surface equivalent (sev) (11.4 mmHg) (paragraph 21-5.6.4). 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 appropriate to the rate of decompression:

Depth	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

- 21-5.4.5.6 **Preventing Inadvertent Early Surfacing.** Upon arrival at 4 feet, decompression should be stopped for 4 hours. At the end of 4 hours at 4 feet, decompress to the surface at 1 foot per minute. This procedure prevents inadvertent early surfacing.

- 21-5.4.5.7 **Time Intervals.** The travel time between subsequent steps 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.

- 21-5.4.5.8 **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 oxygen toxicity (paragraph 21-5.5.6.2).

- 21-5.4.5.9 ***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 as outlined in paragraph 21-5.5.7.
- 21-5.4.5.10 ***Ancillary Care.*** Patients on Treatment Table 7 requiring intravenous and/or drug therapy should have these administered in accordance with paragraph 21-5.5.7 and paragraph 21-5.5.7.1.
- 21-5.4.5.11 ***Life Support.*** Before committing to a Treatment Table 7, the life-support considerations in paragraph 21-5.6 must be addressed. Do not commit to a Treatment Table 7 if the internal chamber temperature cannot be maintained at 85°F (29.4°C) or less (paragraph 21-5.6.5).
- 21-5.4.5.12 ***Abort Procedures.*** In some cases, a Treatment Table 7 may have to be terminated early. If extenuating circumstances dictate early decompression and less than 12 hours have elapsed since treatment was begun, decompression may be accomplished using the appropriate 60-foot Air Decompression Table as modified below. The 60-foot Air Decompression Tables may be used even if time was spent between 60 and 165 feet (e.g., on Table 4 or 6A), as long as at least 3 hours have elapsed since the last excursion below 60 feet. If less than 3 hours have elapsed, or if any time was spent below 165 feet, use the Air Decompression Table appropriate to the maximum depth attained during treatment. All stops and times in the Air Decompression Table should be followed, but oxygen-breathing periods should be started for all chamber occupants as soon as a depth of 30 feet is reached. All chamber occupants should continue oxygen-breathing periods of 25 minutes on 100 percent oxygen, followed by 5 minutes on air, until the total time breathing oxygen is one-half or more of the total decompression time.

If more than 12 hours have elapsed since treatment was begun, the decompression schedule of Treatment Table 7 shall be used. In extreme emergencies, the abort recommendations (paragraph 21-8) may be used if more than 12 hours have elapsed since beginning treatment.

- 21-5.4.6 ***Treatment Table 8.*** Treatment Table 8 is an adaptation of a Royal Navy Treatment Table 65 mainly for treating deep uncontrolled ascents (see Volume 3) 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 Table 8 schedule from 60 feet is the same as Treatment Table 7.
- 21-5.4.7 ***Treatment Table 9.*** Treatment Table 9 is a hyperbaric oxygen treatment table using 90 minutes of oxygen at 45 feet. This table is recommended by the Diving Medical Officer cognizant of the patient's medical condition. Treatment Table 9 is used for the following:

- Residual symptoms from AGE/DCS
- Carbon monoxide or cyanide poisoning
- Smoke inhalation
- Medical hyperbaric oxygen therapy

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.

- 21-5.5 Tending the Patient.** When conducting a recompression treatment, at least one qualified tender shall be inside the chamber (Figure 21-1). The inside tender shall be familiar with all treatment procedures and the signs, symptoms, and treatment of all diving-related disorders.



Figure 21-1. Inside Tender.

- 21-5.5.1 DMO or DMT Inside Tender.** If it is known before the treatment begins that involved medical aid must be administered to the patient, 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.
- 21-5.5.2 Use of DMO.** If only one Diving Medical Officer is present, the Medical Officer's time in the chamber should be kept to a minimum because effectiveness in directing the treatment is greatly diminished when inside the chamber. If periods in the chamber are necessary, visits should be kept within no-decompression limits if possible.
- 21-5.5.3 Patient Positioning.** Inside the chamber, the tender ensures that the patient is lying down and positioned to permit free blood circulation to all extremities. The tender closes and secures the inner lock door and pressurization begins at 20 fpm.

- 21-5.5.4 **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.
- 21-5.5.5 **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 designates the treatment table to be used. The inside tender is also responsible for:
- Releasing the door latches (dogs) after a seal is made
 - Communications 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
- 21-5.5.6 **Oxygen Breathing and Toxicity During Treatments.** During prolonged treatments on Treatment Tables 4, 7, or 8, pulmonary oxygen toxicity may develop. Acute CNS oxygen toxicity may develop on any oxygen treatment table. Refer to paragraph 19-2.4 for further discussion of oxygen toxicity during in-water dives.
- 21-5.5.6.1 **Central Nervous System Oxygen Toxicity.** When employing the oxygen treatment tables, tenders must be particularly alert for the early warning signs of CNS oxygen toxicity. The warning signs can be remembered readily by using the mnemonic VENTIDC (Vision, Ears, Nausea, Twitching\Tingling, Irritability, Dizziness, Convulsions). For additional information, refer to paragraph 19-2.4.2.
- 21-5.5.6.1.1 **Procedures in the Event of Oxygen Toxicity.** At the first sign of CNS oxygen toxicity, the patient should be removed from oxygen and allowed to breathe chamber air. Oxygen breathing may be restarted 15 minutes after all symptoms have subsided. If symptoms of CNS oxygen toxicity develop again, interrupt oxygen breathing for another 15 minutes. If CNS oxygen toxicity develops a third time, contact a Diving Medical Officer as soon as possible to modify oxygen breathing periods to meet requirements.
- 21-5.5.6.1.2 **Interruptions Due to Oxygen Toxicity.** CNS oxygen toxicity is unlikely in resting individuals at 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. Figure

21-7, Figure 21-8, and Figure 21-9 explain how to handle interruptions in oxygen breathing on Treatment Tables 5, 6, and 6A. Treatment Tables 4, 7, and 8 do not require compensatory lengthening or alteration if oxygen breathing must be interrupted. If an oxygen convulsion occurs, discontinue oxygen and keep the patient from harm. Inserting an airway device or bite block is unnecessary while the patient is convulsing; it is not only difficult but may cause harm if attempted.

21-5.5.6.2 **Pulmonary Oxygen Toxicity.** Pulmonary oxygen toxicity is unlikely to develop on Treatment Tables 5, 6, or 6A. On Treatment Tables 4, 7, or 8, the large amounts of oxygen that may have to be administered may result in end-inspiratory discomfort, progressing to substernal burning and severe pain on inspiration. Substernal burning is normally cause for discontinuing oxygen breathing in patients who are responding well to treatment. 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. The Diving Medical Officer may tailor the above guidelines to suit individual patient response to treatment.

21-5.5.7 **Ancillary Care and Adjunctive Treatments.** Drug therapy should be administered only after consultation with a Diving Medical Officer. Chamber tenders shall be adequately trained and be capable of administering prescribed treatments. 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. Patients 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 only Dextrose (D5W) as they may contribute to edema as the sugar is metabolized. 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. A gauge of proper hydration is a clear colorless urine.

21-5.5.7.1 **Steroids.** There is no consensus on the usefulness of adjunctive therapy, other than IV fluids. The most frequently recommended adjunctive therapy is dexamethasone (Decadron), based on the following reasons:

- It decreases tissue swelling (edema)
- It decreases tissue inflammation
- It decreases leaking of blood vessels
- It helps prevent histamine release

General opinion is that spinal cord and brain edema cause many late-appearing neurologic problems in DCS. Research suggests that dexamethasone is not useful during treatment of AGE. In this case steroids may be useful but their efficiency has not been proven. They do not become effective, however, for 4 to 6 hours after intravenous introduction. Therefore, administer these drugs early in the treatment. Do not delay recompression while preparing these drugs. For cerebral edema, the initial recommended dose is 30 mg/kg IV bolus, followed by a constant infusion of 5.4 mg/kg/hr of methylprednisolone. Continue infusion for 23 hours. No benefit has been documented if steroid treatment was not started within 8 hours of symptoms.

21-5.5.7.2 **Lidocaine.** Several studies suggest that Lidocaine used in antiarrhythmic doses (loading dose 1.5 mg/kg drip rate 1 mg/min) may be useful. Its mechanism of action for treating DCS has been hypothesized as:

- Reduction of cerebral metabolic rate
- Preservation of cerebral blood flow
- Reduction leukocyte adherence to damaged endothelium

NOTE Steroids or other drugs can be used only upon the prescription by and under supervision of a Diving Medical Officer.

21-5.5.8 **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 Tables 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 21-5.5.7.

21-5.6 **Recompression Chamber Life-Support Considerations.** The short treatment tables (Oxygen Treatment Tables 5, 6, 6A; 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.

21-5.6.1 **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.

1. 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.
2. The Outside Tender is responsible for the operation of gas supplies, ventilation, pressurization, and exhaust of the chamber.
3. The Inside Tender is familiar with the diagnosis and treatment of diving-related sicknesses.

21-5.6.2 **Optimum Manning Requirements.** The optimum team for conducting recompression operations consists of four individuals:

1. The Diving Supervisor is in complete charge at the scene of the operation.
2. The Outside Tender #1 is responsible for the operation of the gas supplies, ventilation, pressurization, and exhaust of the chamber.
3. The Outside Tender #2 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.
4. The Inside Tender is familiar with the diagnosis and treatment of diving-related sicknesses.

21-5.6.2.1 **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. Patients 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.

21-5.6.2.2 **Required Consultation by a Diving Medical Officer.** A Diving Medical Officer shall be consulted, 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.

21-5.6.3 **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 19 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 21-5.6.6 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 19 percent and 25 percent. If chamber

oxygen goes above 25 percent, ventilation with air should be used to bring the oxygen percentage down.

- 21-5.6.4 **Carbon Dioxide Control.** Ventilation of the chamber in accordance with paragraph 21-5.6.6 will ensure that carbon dioxide produced metabolically does not cause the chamber carbon dioxide level to exceed 1.5 percent SEV (11.4 mmHg).
- 21-5.6.4.1 **Carbon Dioxide Monitoring.** Chamber carbon dioxide should be monitored with electronic chamber carbon dioxide monitors. Monitors generally read CO₂ percentage once chamber air has been exhausted to the surface. The CO₂ percent reading at the surface 1 ata must be corrected for depth. To keep chamber CO₂ below 1.5 percent SEV (11.4 mmHg), the surface CO₂ monitor values should remain below 0.8 percent with chamber depth at 30 feet, 0.54 percent with chamber depth at 60 feet, and 0.25 percent with the chamber at 165 feet. If the CO₂ analyzer is within the chamber, no correction to the CO₂ readings is necessary.
- 21-5.6.4.2 **Carbon Dioxide Scrubbing.** If the chamber is equipped with a carbon dioxide scrubber, the absorbent should be changed when the partial pressure of carbon dioxide 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 CO₂ at acceptable levels. With multiple or working chamber occupants, supplemental ventilation may be necessary to maintain chamber CO₂ at acceptable levels.
- 21-5.6.4.3 **Carbon Dioxide Absorbent.** CO₂ absorbent may be used beyond the expiration date, when used in a recompression chamber scrubber unit, when the recompression chamber is equipped with a CO₂ monitor. When employed in a recompression chamber that has no CO₂ monitor, CO₂ absorbent in an opened but resealed bucket may be used until the expiration date on the bucket is reached. Pre-packed, double-bagged canisters shall be labeled with the expiration date from the absorbent bucket.
- 21-5.6.5 **Temperature Control.** If possible, internal chamber temperature should be maintained at a level comfortable to the occupants. Cooling can usually be accomplished by chamber ventilation in accordance with paragraph 21-5.6.6. 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 21-4. Never commit to a treatment table that will expose the chamber occupants to greater temperature/time combinations than listed in Table 21-4 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 (29.4°C) is always desirable, no matter which treatment table is used.

Table 21-4. Maximum Permissible Recompression Chamber Exposure Times at Various Temperatures.

Internal Temperature	Maximum Tolerance Time	Permissible Treatment Tables
Over 104°F (40°C)	Intolerable	No treatments
95-104°F (34.4-40°C)	2 hours	Table 5, 9
85-94°F (29.4-34.4°C)	6 hours	Tables 5, 6, 6A, 1A, 9
Under 85°F (29.4°C)	Unlimited	All

NOTE
Internal chamber temperature can be kept considerably below ambient by venting or by using an installed chiller unit. Internal chamber temperature can be measured using electronic, bimetallic, alcohol, or liquid crystal thermometers. **Never 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.**

21-5.6.5.1 **Patient Hydration.** Successful treatment of decompression sickness depends upon adequate hydration. Thirst is an unreliable indicator of the water intake necessary to compensate for heavy sweating, and isolation of the patient within the recompression chamber makes it difficult to assess his overall fluid balance. By providing adequate hydration and following the temperature/time guidelines in Table 21-4, heat exhaustion and heat stroke can be avoided. If the chamber temperature is above 85°F (29.4°C), tenders should monitor patients for signs of thermal stress. If the chamber temperature is above 85°F, chamber occupants should drink approximately one liter of water hourly; below 85°F they should drink an average of one-half liter hourly. Clear colorless urine in patients and tenders is a good indication of adequate hydration.

21-5.6.6 **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. Chamber ventilation procedures are presented in paragraph 22-5.4. 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.

- 21-5.6.7 **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.
- 21-5.6.8 **Inside Tenders.** For Type I decompression sickness, one qualified inside tender is required. For Type II decompression sickness, medical personnel may have to be locked into the chamber as the patient's condition dictates. If 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 will not be able to aid the treatment as well and consultation with other medical personnel becomes more difficult.
- 21-5.6.8.1 **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.
- 21-5.6.8.1.1 **Table 4.** On Table 4, tenders are required to breathe oxygen for 2 hours before leaving 30 feet and for 2 additional hours during decompression from 30 feet to the surface.
- 21-5.6.8.1.2 **Table 5.** On Table 5, oxygen should be breathed by the tender during the final 30-minute ascent to the surface. If the tender has had a previous hyperbaric exposure, an additional 20 minutes of oxygen breathing is required at 30 feet prior to ascent. (See Table 21-6.)
- 21-5.6.8.1.3 **Table 6.** For an unmodified Table 6 or when there has been only a single extension at 60 or 30 feet, the tender breathes 100 percent oxygen for the final 30 minutes at 30 feet and during ascent to the surface. If there has been more than one extension, oxygen breathing is done for the last 60-minute period at 30 feet and during ascent to the surface. If the tender has had a dive/hyperbaric exposure within the past 12 hours, an additional 60-minute oxygen period at 30 feet is required. (See Table 21-6.)
- 21-5.6.8.1.4 **Table 6A.** For an unmodified Table 6A or when there has been only a single extension at 60 or 30 feet, the tender breathes 100 percent oxygen for the final 60 minutes at 30 feet and during ascent to the surface. If there has been more than one extension, oxygen breathing is done for 90 minutes at 30 feet and during ascent to the surface. If the tender has had a dive/hyperbaric exposure within the past 12 hours, an additional 60-minutes of oxygen at 30 feet is required. (See Table 21-6.)
- 21-5.6.8.1.5 **Table 9.** On Table 9, the tender breathes 100 percent oxygen during the last 15 minutes at 45 feet and during ascent to the surface, regardless of the ascent rate used.

21-5.6.8.1.6 **Tending Frequency.** Normally, tenders should allow a surface interval of at least 12 hours between consecutive treatments on 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 12-hour surface interval if oxygen is breathed at 30 feet and shallower as outlined above. Minimum surface intervals for Tables 1A, 2A, 3, 4, and 7 shall be strictly observed.

21-5.7 Loss of Oxygen During Treatment. Loss of oxygen-breathing capability during oxygen treatments is a rare occurrence. However, should this occur, the following should be done:

If repair can be effected within 15 minutes:

- Maintain depth until repair completed.
- After O₂ is restored, resume treatment at point of interruption.

If repair can be effected after 15 minutes but before 2 hours:

- Maintain depth until repair completed
- After O₂ is restored: If original table was Table 5, 6, or 6A, complete treatment on Table 6 schedule with maximum number of O₂ extensions.

21-5.7.1 **Compensation.** If Table 4, 7, or 8 is being used, no compensation in decompression is needed if O₂ 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.

21-5.7.2 **Switching to Air Treatment Table.** If O₂ breathing cannot be restored in 2 hours switch to 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 an increase in treatment depth deeper than 60 feet is needed, use Treatment Table 4.

21-5.8 Use of High-Oxygen Mixes. High-oxygen N₂O₂/HeO₂ mixtures may be administered during treatment when 100 percent oxygen cannot be tolerated. The premixed gases shown in Table 21-5 may be used over the depth range of 0-225 fsw.

Table 21-5. High-Oxygen Treatment Gas Mixtures.

Depth (fsw)	Mix (HeO ₂ or N ₂ O ₂)	ppO ₂
0–60	100%	1.00–2.82
61–100	50/50	1.42–2.02
101–165	60/40	1.62–2.4
166–225	64/36 (HeO ₂)	2.17–2.8

High-oxygen mixtures can be used for treating patients at depth when no significant improvement was made at 60 fsw. High-oxygen mixtures may also be used for patients experiencing pulmonary oxygen toxicity at 60 fsw and shallower.

Ideally, the ppO₂ of the treatment gas used should be 1.5 to 2.8 ata. Using nitrogen as the background gas is an acceptable practice for treating DCS/AGE. Recent studies suggest that using helium as the background gas may be more beneficial. Using HeO₂ reduces the amount of nitrogen dissolved in the patient's tissue and facilitates the off-gassing of nitrogen.

21-5.9 Treatment at Altitude - Tender Consideration. 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 (paragraph 9-12). 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 TT5, TT6, and TT6A is given below. The requirement pertains both to tenders equilibrated at altitude and to tenders flown directly from sea level to the chamber location.

Table 21-6. Tender Oxygen Breathing Requirements.¹

Treatment Table (TT)	Altitude		
	Surface to 2499 ft.	2500 ft. – 7499 ft.	7500 ft. – 10,000 ft.
TT5 without extension	:00	:00	:00
TT5 with extension @ 30 fsw	:00	:00	:20
TT6 ² up to one extension @ 60 fsw or 30 fsw	:30	:60	:90
TT6 ² more than one extension	:60	:90	:120
TT6A ² up to one extension @ 60 fsw or 30 fsw	:60	:120	:150 ³
TT6A ² more than one extension	:90	:150 ³	:180 ³
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 12 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.		
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.		

Contact NAVSEA 00C for guidance on tender oxygen administration for other treatment tables.

21-6 POST-TREATMENT CONSIDERATIONS

Tenders on Tables 5, 6, 6A, 1A, 2A, or 3 should have a minimum of a 12-hour surface interval before no-decompression diving and a minimum of a 24-hour surface interval before dives requiring decompression stops. Tenders on Tables 4, 7, and 8 should have a minimum of a 48-hour surface interval prior to diving.

- 21-6.1 Post-Treatment Observation Period.** After a treatment, patients treated on a Treatment Table 5 should remain at the recompression chamber facility for 2 hours. Patients 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 remain at the recompression chamber facility for 6 hours. These times may be shortened upon the recommendation of a Diving Medical Officer, 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 of a recompression facility for 24 hours and should not be left alone during that period.
- 21-6.2 Post-Treatment Transfer.** Patients 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. Patients 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.
- 21-6.3 Inside Tenders.** 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 1 hour. If they were tending for Treatment Table 4, 7, or 8, inside tenders should also remain within 60 minutes of a recompression facility for 24 hours.
- 21-6.4 Flying After Treatments.** Patients with residual symptoms should fly only with the concurrence of a Diving Medical Officer. Patients 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.
- 21-6.4.1 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.
- 21-6.4.2 Tender Surface Interval.** Tenders on Tables 5, 6, 6A, 1A, 2A, or 3 should have a 24-hour surface interval before flying. Tenders on tables 4, 7, and 8 should not fly for 72 hours.

- 21-6.5 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. 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. Patients 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 33 feet may also be used. As many oxygen breathing periods (30 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 90 minutes. A practical maximum bottom time is 3 to 4 hours at 33 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.
- 21-6.5.1 Additional Recompression Treatments.** Additional recompression treatments are indicated as long as they are prescribed by a Diving Medical Officer. In treating residual symptoms, no response to recompression may occur on the first one or two treatments. In these cases, the Diving Medical Officer is the best judge as to the number of treatments. Consultation with NEDU or NDSTC may be appropriate (phone numbers are listed in paragraph 21-1.4). 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.
- 21-6.6 Returning to Diving after Treatment Table 5.** Divers who meet all of the criteria for treatment using Treatment Table 5, as outlined in paragraph 21-5.4.1 and who have had complete relief, may return to normal diving activity 7 days after surfacing from the Treatment Table 5. If there is any doubt about the presence or absence of Type II symptoms, the diver should be examined by a Diving Medical Officer before resumption of diving.
- 21-6.6.1 Returning to Diving After Treatment Table 6.** Divers who had symptoms of arterial gas embolism, Type II DCS, or Type I DCS requiring a Treatment Table 6 should not dive for at least 4 weeks and should resume diving only upon the recommendation of a Diving Medical Officer.
- 21-6.6.2 Returning to Diving After Treatment Table 4 or 7.** A diver having cardiorespiratory and/or CNS symptoms severe enough to warrant Treatment Table 4 or 7

should not dive for a minimum of 3 months, and not until a thorough review of his case by a Diving Medical Officer has established that return to normal diving activity can be accomplished safely.

21-7 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.

21-8 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.

21-8.1 Death During Treatment. If it appears that the diver being treated has died, a qualified medical personnel shall be consulted before the treatment is aborted. If this is done, then the tenders may be decompressed by completing the treatment table, by following the air decompression schedule (as modified below), or contact NEDU or NDSTC for decompression procedures for the total time since treatment began and the maximum depth attained. The shortest procedure should be used. The exception is Treatment Table 7; the appropriate abort procedure for Table 7 is discussed in paragraph 21-5.4.5.12.

21-8.2 Oxygen Breathing Periods During Abort Procedure. The air decompression schedule used in recompression treatment aborts is modified by having all chamber occupants begin breathing oxygen as soon as a depth of 30 feet or shallower is reached. Oxygen-breathing periods of 25 minutes on oxygen, followed by 5 minutes on air, are continued until the total time on oxygen is one-half or more of the total decompression time. This procedure may be used even if gases other than air (i.e., nitrogen-oxygen or helium-oxygen mixtures) were breathed during treatment. Upon surfacing, chamber occupants are treated as if they had surfaced from a normal dive.

21-8.3 Impending Natural Disasters or Mechanical Failures. Impending natural disasters or mechanical failures may require aborting treatments. 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 above 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.
3. Follow as much of the air decompression schedule (for maximum depth and total time) as possible, breathing 100 percent oxygen continuously.
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 21-4. If no symptoms occurred after the treatment was aborted, follow Treatment Table 6.

21-9 EMERGENCY MEDICAL EQUIPMENT

Every diving activity shall maintain emergency medical equipment that will be available immediately for use at the scene of a diving accident (Figure 21-2). 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.

- 21-9.1 Primary Emergency Kit.** 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 lists of contents presented here are not meant to be restrictive but are considered the minimum requirement. Additional items may be added to suit local medical preferences.
- 21-9.2 Emergency Kits.** The Primary Emergency Kit is described in Table 21-7; the Secondary Emergency Kit is described in Table 21-8a.
- 21-9.2.1 Primary Emergency Kit.** 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.
- 21-9.2.2 Secondary Emergency Kit.** 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.
- 21-9.2.3 Portable Monitor-Defibrillator.** Only commands having recompression chambers with a medical officer attached shall maintain a portable monitor-defibrillator and those drugs listed with an asterisk (*). These drugs need to be in sufficient quanti-



Figure 21-2. Emergency Medical Equipment for TRCS.

ties to support an event requiring Advanced Cardiac Life Support. These drugs/equipment are not required to be in every dive kit when multiple chambers/kits are present in a single command.

21-9.3 Use of Emergency Kits. Unless adequately sealed against increased atmospheric pressure, sterile supplies should be resterilized after each pressure exposure, or, if not exposed, at six-month intervals. Drugs shall be replaced when their expiration date is reached. Not all drug ampules will withstand pressure. Stoppered multidose vials should be vented with a needle during pressurization and then discarded if not used.

21-9.3.1 Modification of Emergency Kits. Because the available facilities may differ on board ship, at land-based diving installations, and at diver training or experimental units, the responsible Diving Medical Officer or Diving Medical Technician will have to modify the emergency kits to suit the local needs. Both kits should be taken to the recompression chamber or scene of the accident. Each kit is to contain a list of contents. Each time the kit is opened, it shall be inventoried and each item checked for proper working order and then re-sterilized. Sterile supplies are to be provided in duplicate so that one set can be autoclaved while the other resides in the kit. The kits on-hand are inventoried, unopened, at four-month intervals. Normally, use of the emergency kit is to be restricted to the medical personnel. Concise instructions for administering each drug are to be provided in the kit along with current American Heart Association Advanced Cardiac Life-Support

Table 21-7. Primary Emergency Kit.

Diagnostic Equipment

- Flashlight
- Stethoscope
- Otoscope (Ophthalmoscope)
- Sphygmomanometer (Aneroid type only, case vented for hyperbaric use)
- Reflex hammer
- Tuning Fork (256 cps)
- Sterile safety pins or swab sticks which can be broken for sensory testing
- Tongue depressors

Emergency Treatment Equipment and Medications

- Oropharyngeal airways (#4 and #5 Geudel)
- Self-Inflating Clear Bag-Mask ventilator with medium adult mask
NOTE: Some of these units do not have sufficient bag volume to provide adequate ventilation. Use a Laerdal Resusci Folding Bag II (Adult) or equivalent.
- Suction apparatus
- Nonflexible plastic suction tips (Yankauer Suction Tip)
- Large-bore needle and catheter (12 or 14 gauge) for cricothyrotomy or relief of tension pneumothorax
- Chest tube
- Small Penrose drain, Heimlich valve, or other device to provide one-way flow of gas out of the chest
- Christmas tree adapter (to connect one-way valve to chest tube)
- Adhesive tape (2-inch waterproof)
- Elastic-Wrap bandage for a tourniquet (2- and 4-inch)
- Tourniquet
- Bandage Scissors
- #11 knife blade and handle
- Curved Kelly forceps
- 10% povidone-iodine swabs or wipes
- 1% lidocaine solution
- #21 ga. 1½-inch needles on 5 cc syringes
- Cravets
- 20 cc syringe

NOTE 1: One Primary Emergency Kit is required per chamber system (i.e., TRCS requires one).

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.**

Table 21-8a. Secondary Emergency Kit (sheet 1 of 2).

Emergency Airway Equipment

- Cuffed endotracheal tubes with adapters (7-9.5 mm)
- Syringe and sterile water for cuff inflation (10 cc)
- Malleable stylet (approx. 12" in length)
- Laryngoscope blades (McIntosh #3 and #4, Miller #2 and #3)
- Sterile lubricant
- Soft-rubber suction catheters
- #32F and #34F latex rubber nasal airways
- 5% or 2% lidocaine ointment

Drugs

- Lactated Ringer's Solution (3 ea 1-liter bags)
- Normal saline (2 ea 1-liter bags, 4 ea 250-ml bags for mixing drugs)
- * Atropine for injection (2 ea 1-mg)
- * Sodium bicarbonate for injection (8 ea mEq)
- * Verapamil for injection (4 ea 5-mg)
- * Dexamethasone for injection (4 ea 5-ml, 4 ea mg/ml)
- * Epinephrine (1 /10,000) for injection (4 ea 1-mg)
- * Lidocaine for injection (4 ea 100-mg)
- * Diphenhydramine hydrochloride for injection (4 ea 50-mg)
- * Diazepam for injection (4 ea 10-mg)
- * Sodium phenytoin for injection (4 ea 250-mg)
- * Procainamide hydrochloride for injection (2 ea 1,000-mg)
- * Dopamine hydrochloride (4 ea 200-mg)
- * Furosemide for injection (4 ea 20-mg)
- * Bretylium tosylate (3 ea 500-mg)
- * Mannitol (4 ea 12.5-g in 50 ml)
- * Adenosine (4 ea 12-mg)
- * Sterile water for injection
- Aspirin Tablets
- Aspirin rectal suppositories

NOTE 1: Only commands having recompression chambers with a Medical Officer attached shall maintain a portable monitor-defibrillator and those drugs listed with an asterisk (*).

NOTE 2: Whenever possible, preloaded syringe injection sets should be obtained to avoid the need to vent multidose vials or prevent implosion of ampules. Sufficient quantities should be maintained to treat one injured diver.

NOTE 3: One Secondary Emergency Kit is required per chamber system (i.e., TRCS requires one).

Table 21-8b. Secondary Emergency Kit (sheet 2 of 2).

Miscellaneous

- Nasogastric tube
- Urinary catheterization set with collection bag (Foley type)
- Catheter and needle unit, intravenous (16- and 18-gauge - 4 ea)
- Intravenous infusion sets (4)
- Intravenous infusion extension sets with injection ports (2)
- Straight and curved hemostats (2 ea)
- Blunt straight surgical scissors
- Thermometer (non-mercury type, high and low reading preferably)
- Syringes (2, 5, 10 and 30 cc)
- Sterile needles (18-, 20-, and 22- gauge)
- 3-way stopcocks
- Wound closure instrument tray
- Needle driver
- Assorted suture material (with and without needles)
- Assorted scalpel blades and handle
- Surgical soap
- Sterile towels
- Sterile gloves (6-8)
- Gauze roller bandage, 1-inch and 2-inch, sterile
- 10% povidone-iodine swabs or wipes
- Cotton Balls
- Gauze pads, sterile, 4-inch by 4-inch
- Band aids
- Splints

NOTE: A portable oxygen supply with an E cylinder (approximately 669 liters of oxygen) is recommended whenever possible in the event the patient needs to be transported to another facility.

Treatment of Decompression Sickness Occurring While at a Decompression Stop in the Water

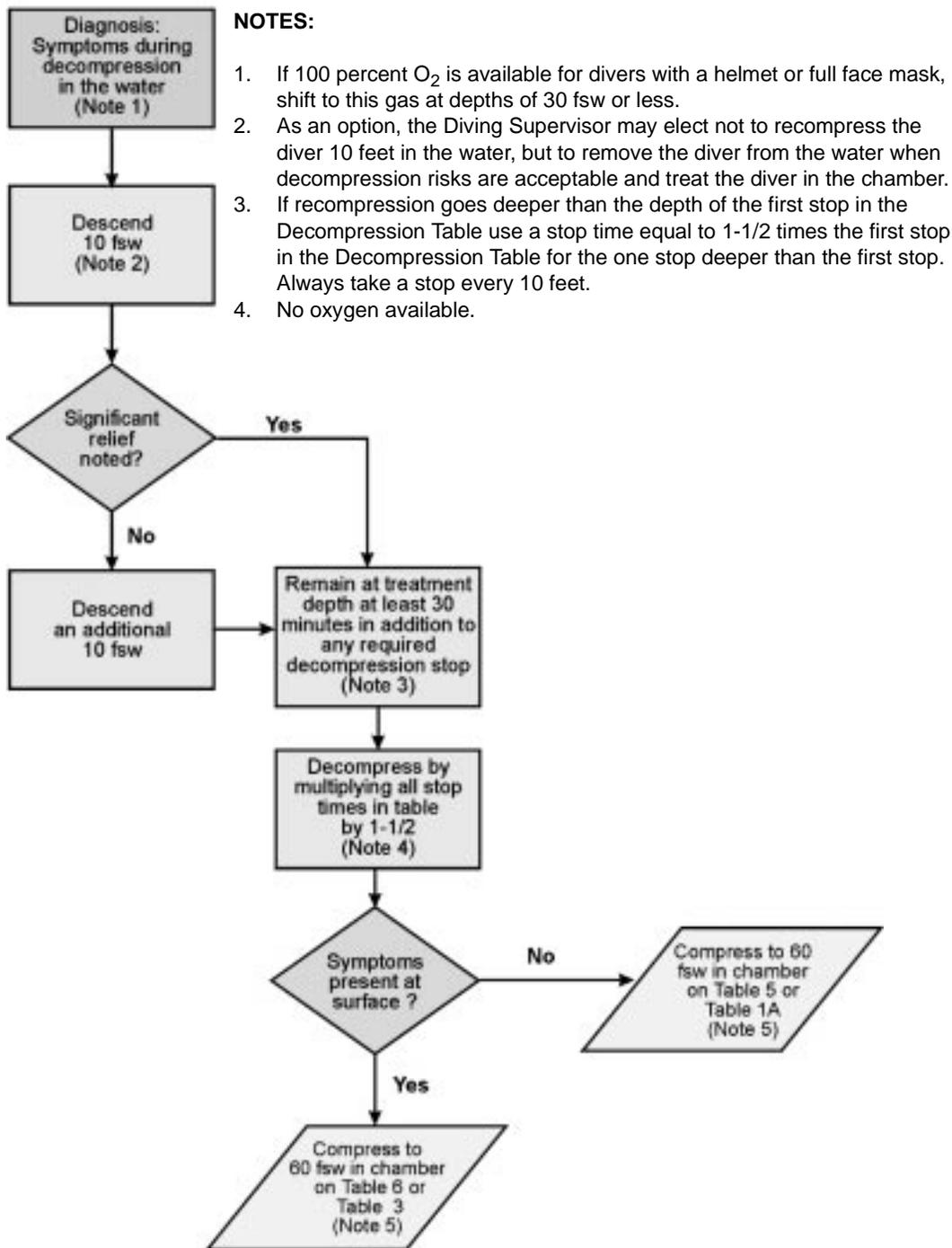
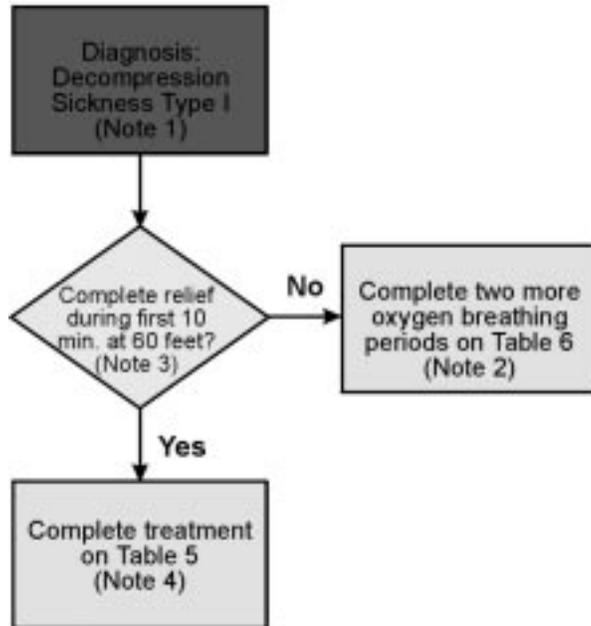


Figure 21-3. Treatment of Decompression Sickness Occurring while at Decompression Stop in the Water.

Treatment of Type I Decompression Sickness

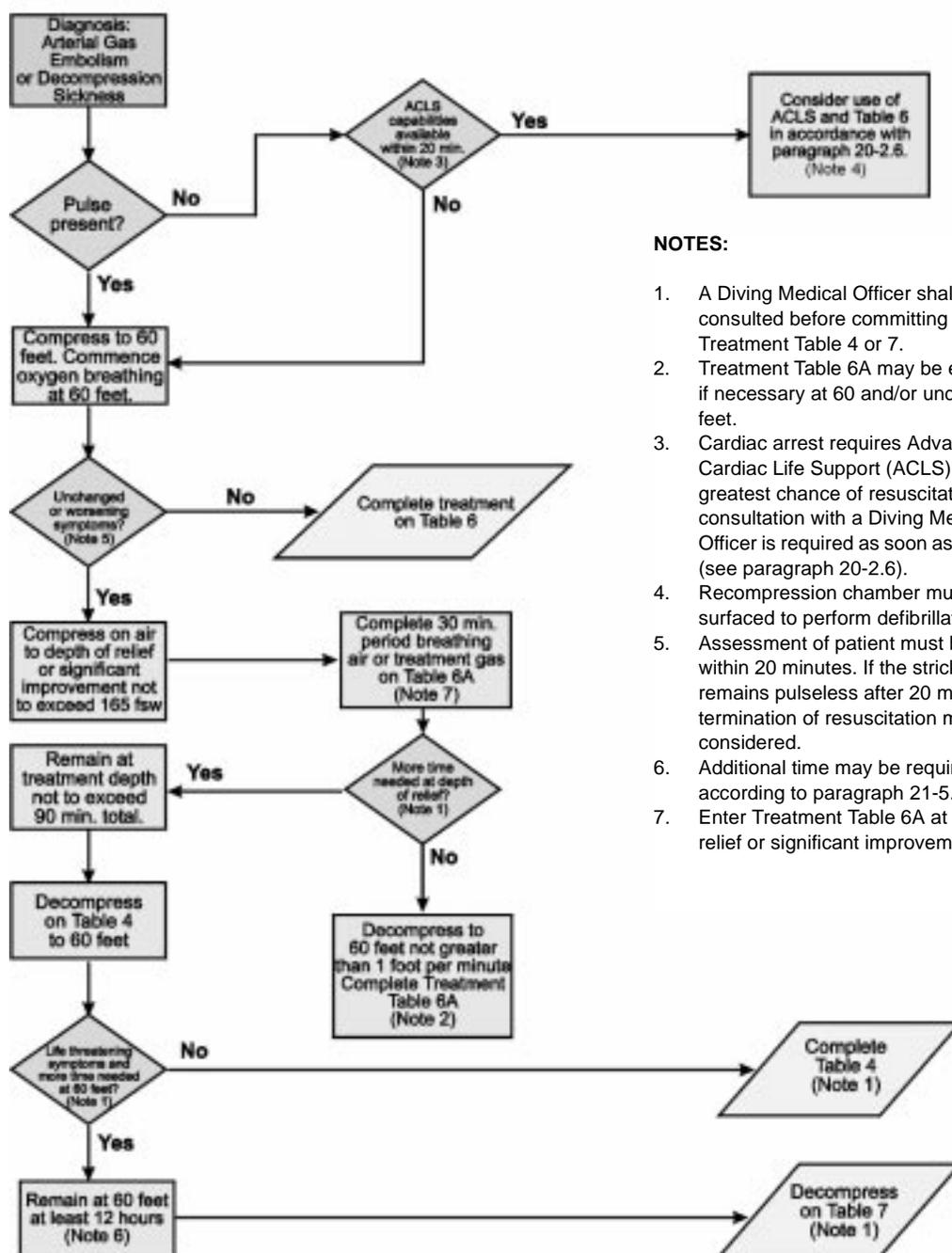


NOTES

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.

Figure 21-4. Decompression Sickness Treatment from Diving or Altitude Exposures.

Treatment of Arterial Gas Embolism or Decompression Sickness



NOTES:

1. A Diving Medical Officer shall be consulted before committing to a Treatment Table 4 or 7.
2. Treatment Table 6A may be extended if necessary at 60 and/or under 30 feet.
3. Cardiac arrest requires Advanced Cardiac Life Support (ACLS). For the greatest chance of resuscitation consultation with a Diving Medical Officer is required as soon as possible (see paragraph 20-2.6).
4. Recompression chamber must be surfaced to perform defibrillation.
5. Assessment of patient must be made within 20 minutes. If the stricken diver remains pulseless after 20 minutes, termination of resuscitation may be considered.
6. Additional time may be required according to paragraph 21-5.4.5.4.
7. Enter Treatment Table 6A at depth of relief or significant improvement.

Figure 21-5. Treatment of Arterial Gas Embolism or Decompression Sickness.

Treatment of Symptom Recurrence

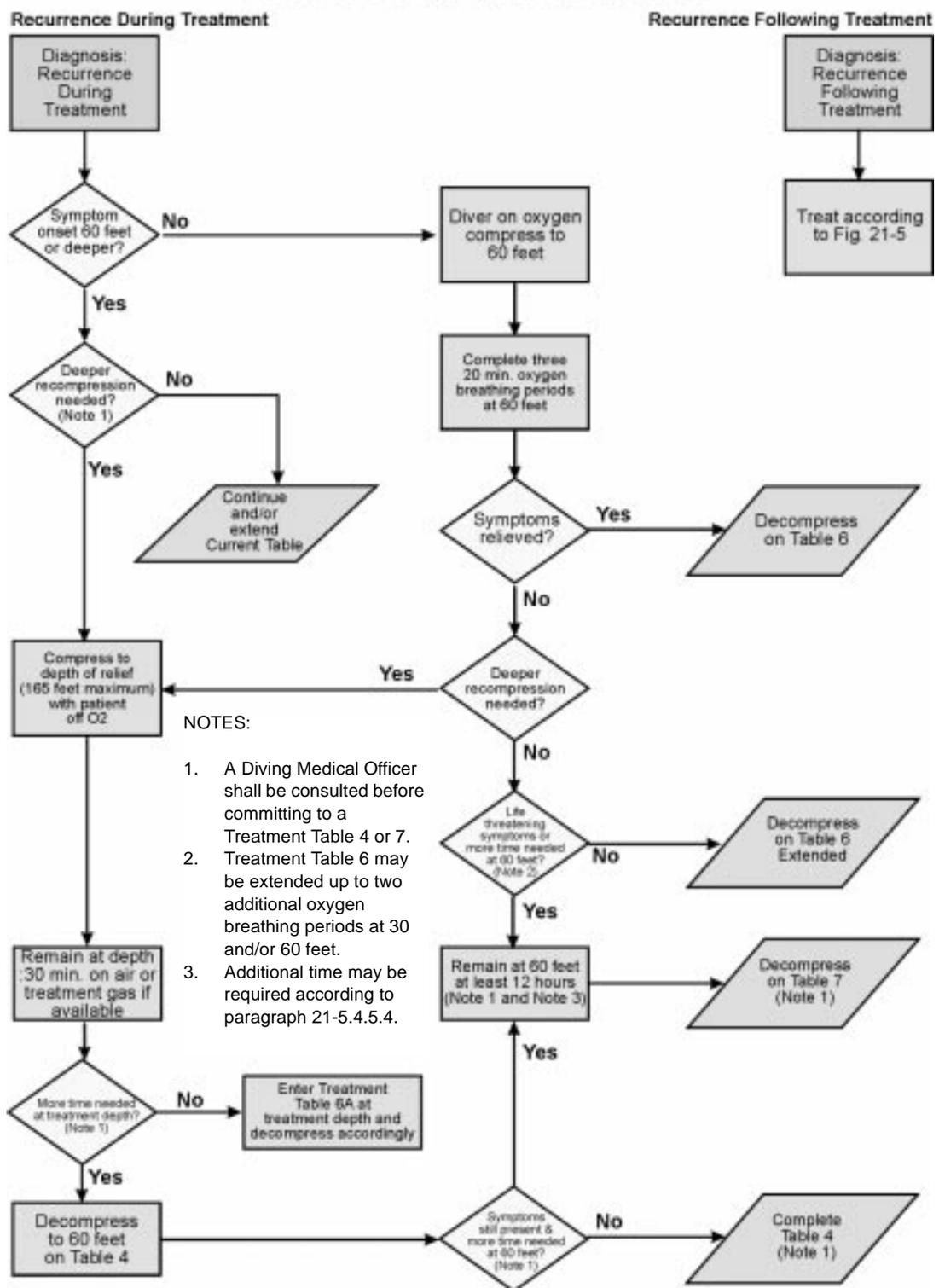


Figure 21-6. Treatment of Symptom Recurrence.

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 21-5.5.6.1.1)
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 O₂ during ascent from the 30-foot stop to the surface. If the tender had a previous hyperbaric exposure in the previous 12 hours, an additional 20 minutes of oxygen breathing is required prior to ascent.

Treatment Table 5 Depth/Time Profile

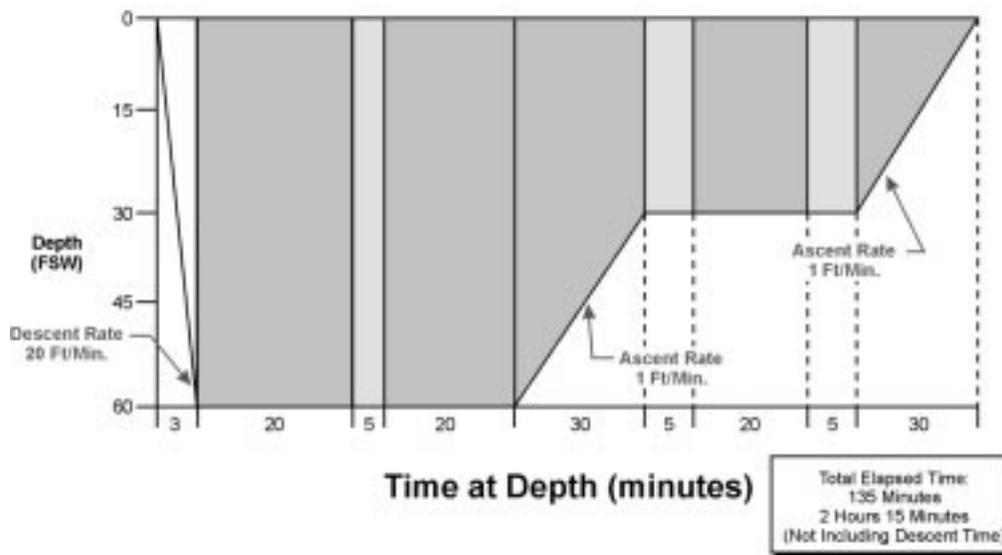


Figure 21-7. Treatment Table 5.

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 21-5.5.6.1.1).
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 O₂ 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 O₂ breathing at 30 feet is increased to 60 minutes. If the tender had a hyperbaric exposure within the past 12 hours an additional 60-minute O₂ period is taken at 30 feet.

Treatment Table 6 Depth/Time Profile

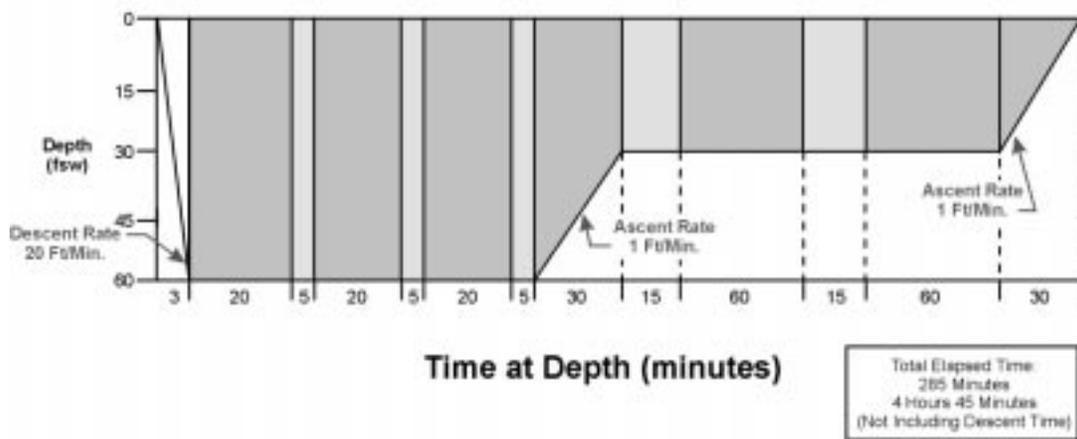


Figure 21-8. Treatment Table 6.

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-O₂ treatment gas, it may be administered at 165 fsw and shallower, not to exceed 2.8 ata O₂ in accordance with paragraph 21-5.7. 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 21-5.5.6.1.1).
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. Tenders breathes 100 percent O₂ 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 O₂ breathing at 30 fsw is increased to 90 minutes. If the tender had a hyperbaric exposure within the past 12 hours, an additional 60 minute O₂ 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

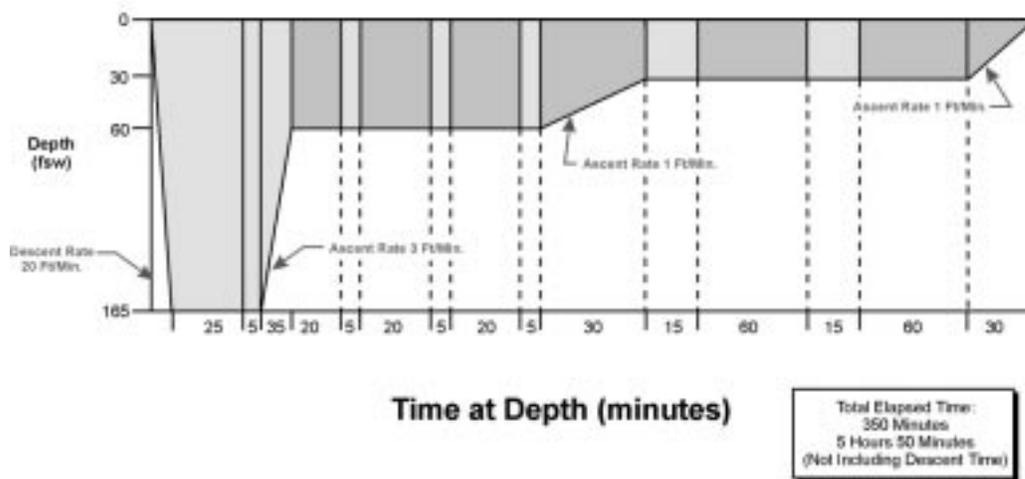


Figure 21-9. Treatment Table 6A.

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 21-5.4.4.2).
5. Ensure life-support considerations can be met before committing to a Table 4. (see paragraph 21-5.6) 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-O₂ treatment gas, it may be administered at 165 fsw, not to exceed 2.8 ata O₂. Treatment gas is administered for 25 minutes interrupted by 5 minutes of air.

Treatment Table 4 Depth/Time Profile

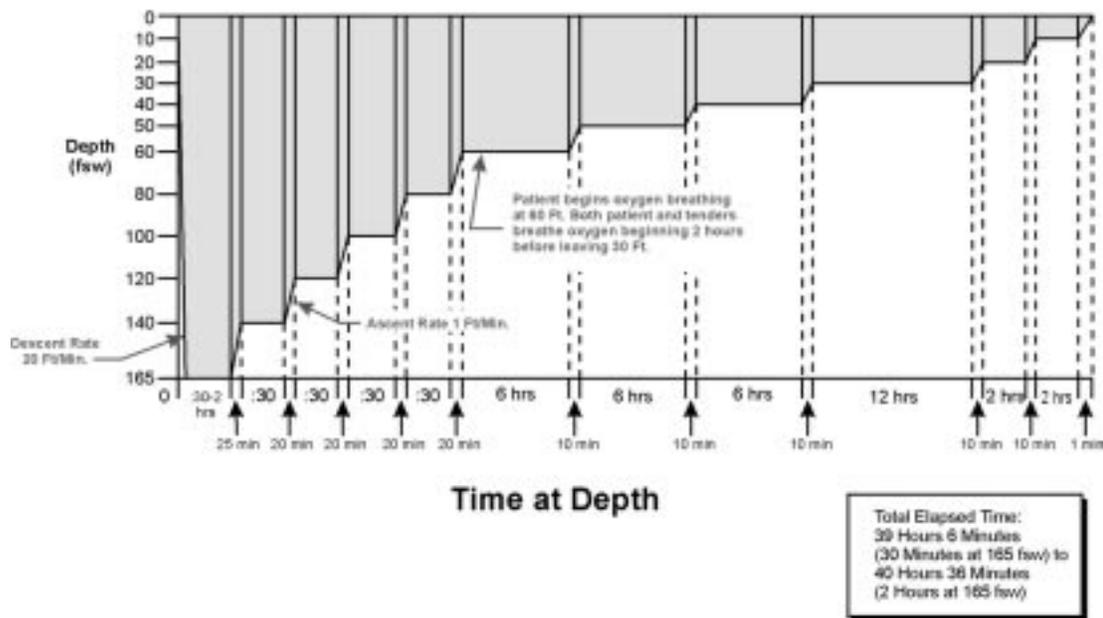


Figure 21-10. Treatment Table 4.

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 O₂ concentration is 19 percent. Maximum CO₂ concentration is 1.5 percent SEV (11.4 mmHg). Maximum chamber internal temperature is 85°F (paragraph 21-5.6.5).
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 shall be consulted before committing to this treatment table.

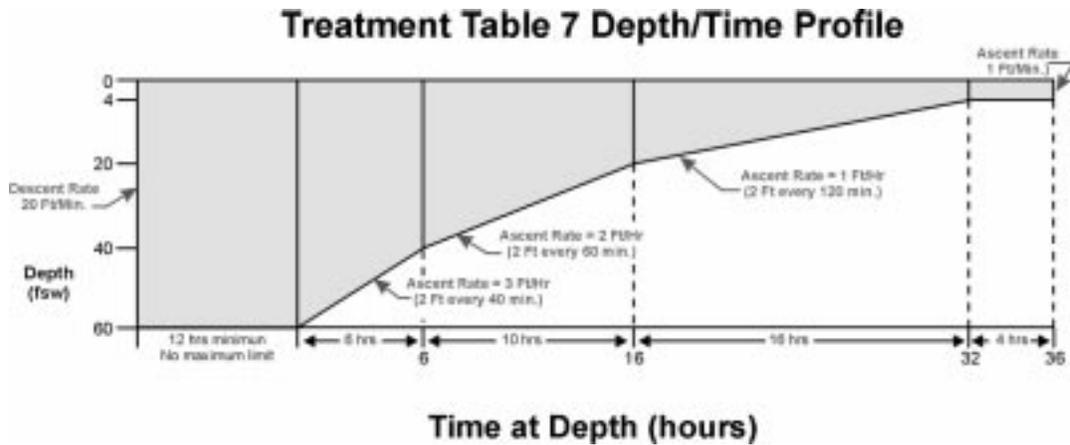


Figure 21-11. Treatment Table 7.

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, helium-oxygen mixture with 16-21 percent oxygen may be breathed by mask to reduce narcosis. At 165 fsw and shallower, a heliox mix with a pO_2 not to exceed 2.8 ata may be given to the diver as a treatment gas. At 60 fsw and shallower, pure oxygen may be given to the diver 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.
6. A high- O_2 treatment mix can be used at treatment depth and during decompression. If high O_2 breathing is interrupted, no lengthening of the table is required.
7. 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.
8. 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

Figure 21-12. Treatment Table 8.

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 21-5.5.6.1.1).
5. Tender breathes 100 percent O₂ during last 15 minutes at 45 feet and during ascent to the surface regardless of ascent rate used.
6. 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.

Treatment Table 9 Depth/Time Profile

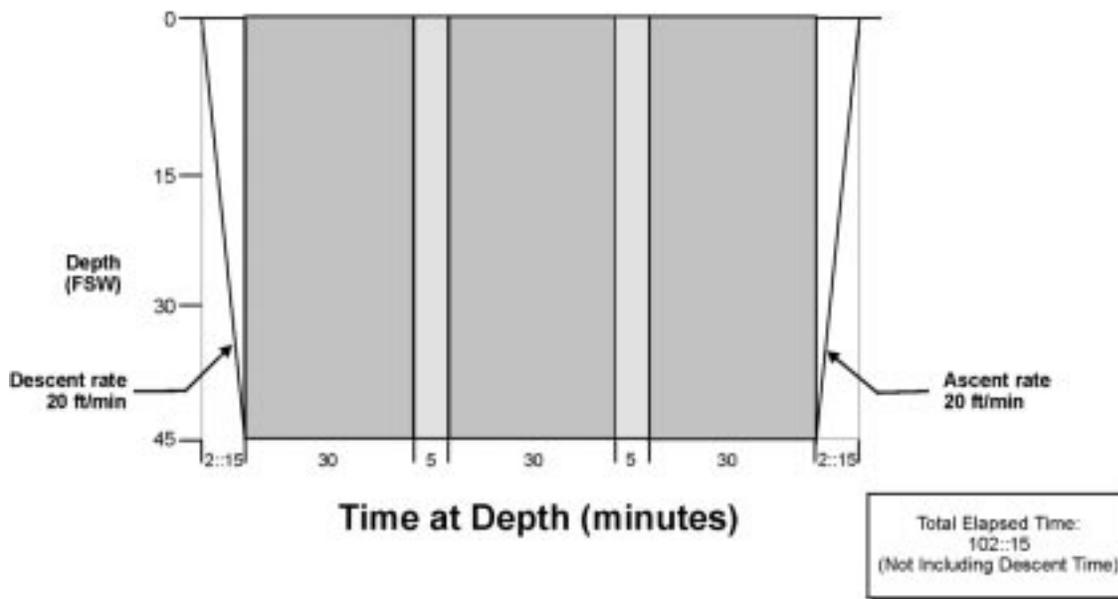


Figure 21-13. Treatment Table 9.

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.

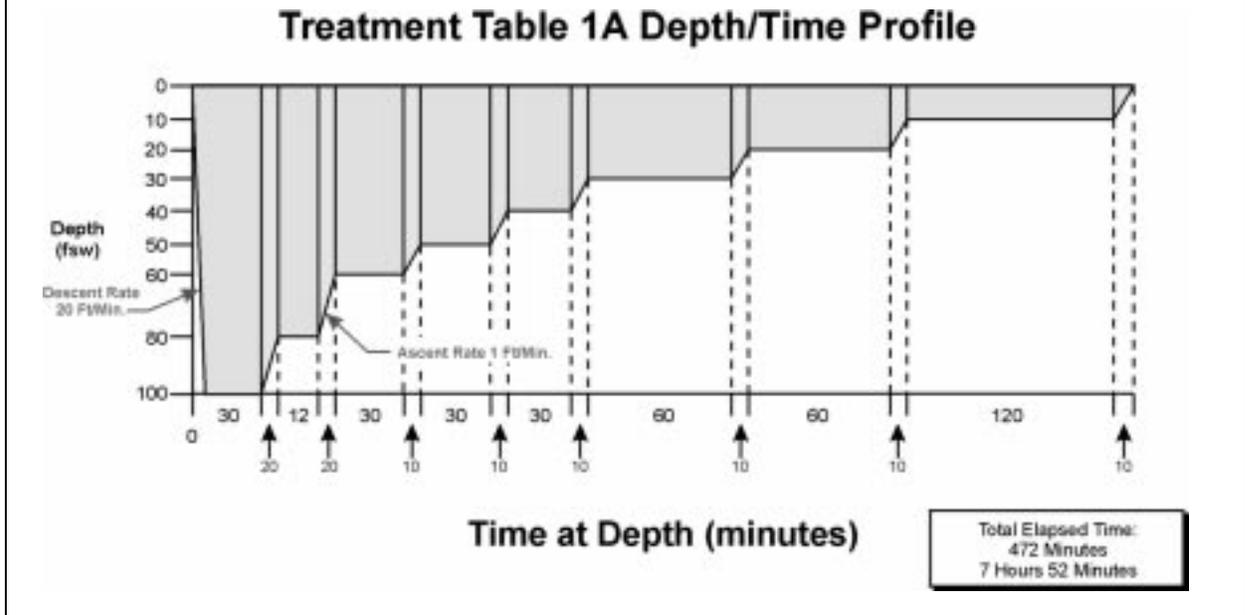


Figure 21-14. Air Treatment Table 1A.

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

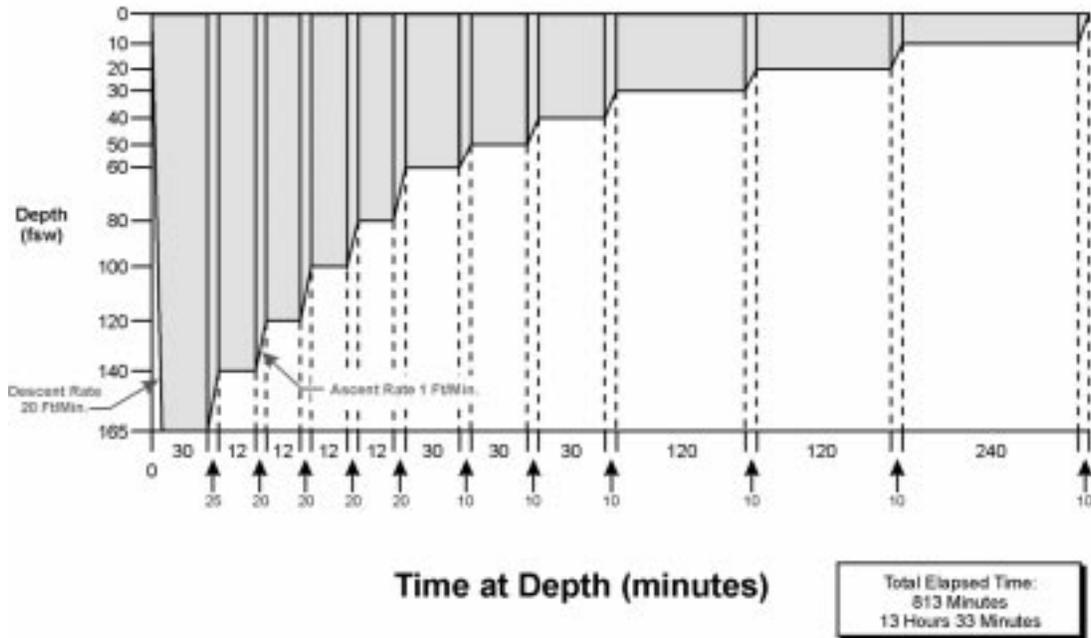


Figure 21-15. Air Treatment Table 2A.

Air Treatment Table 3

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

Treatment Table 3 Depth/Time Profile

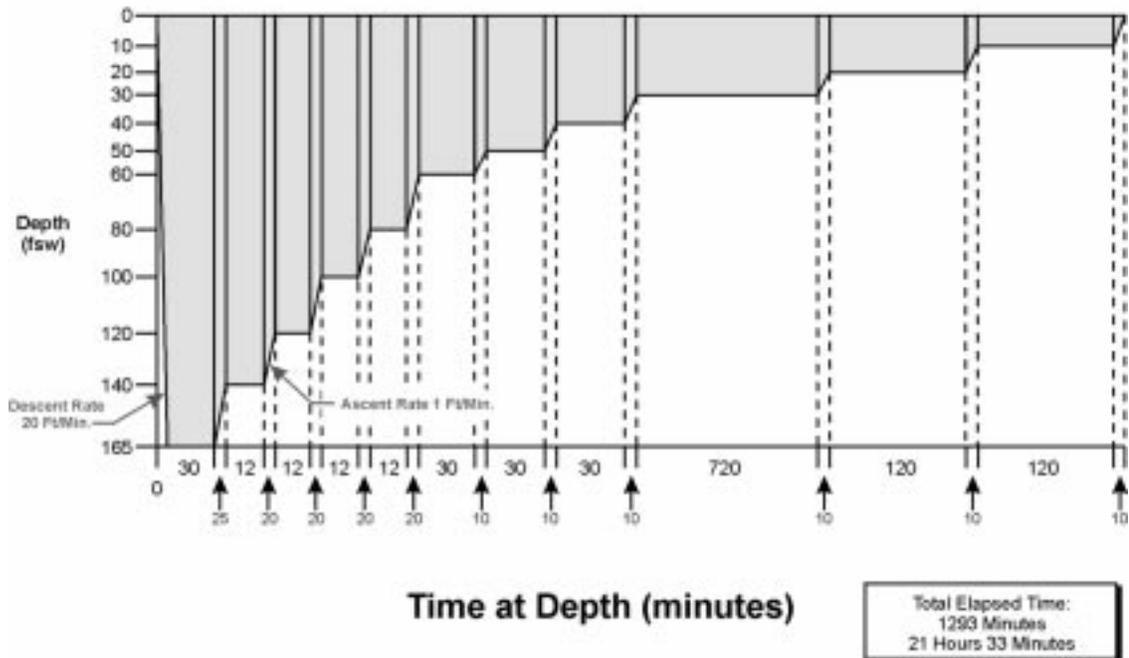


Figure 21-16. Air Treatment Table 3.

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