

Recompression Chamber Operation

22-1 INTRODUCTION

- 22-1.1 Purpose.** Recompression chambers are used for the treatment of decompression sickness, for surface decompression, and for administering pressure tests to prospective divers. Recompression chambers equipped for hyperbaric administration of oxygen are also used in medical facilities for hyperbaric treatment of carbon monoxide poisoning, gangrenous tissue, and other diseases. Decompression surface-supplied diving operations to depths greater than 130 fsw require that a chamber be available at the dive site.
- 22-1.2 Scope.** This chapter will familiarize personnel with the maintenance and operational requirements for recompression chambers.

22-2 DESCRIPTION

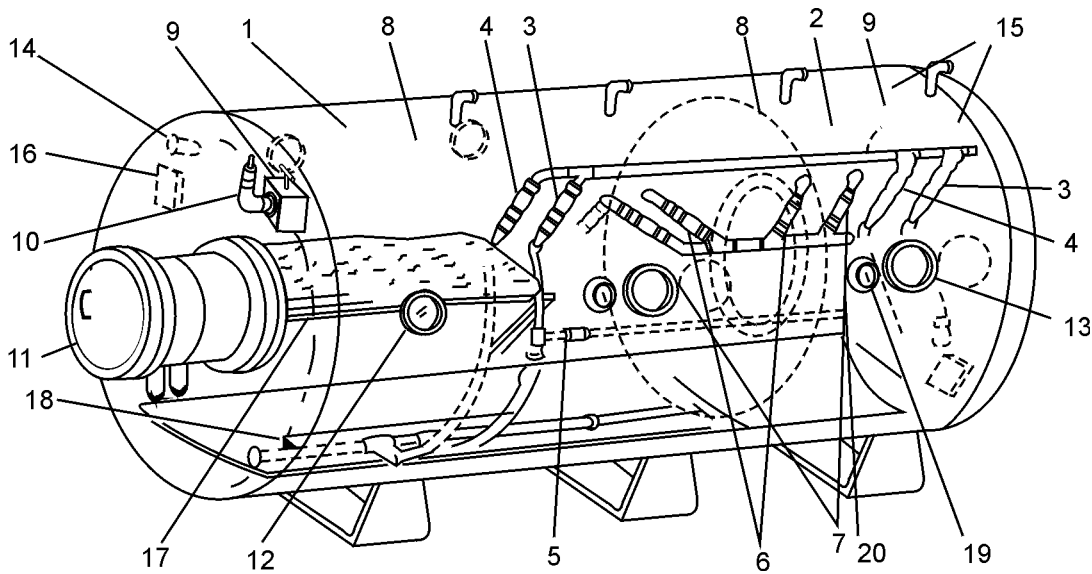
Most chamber-equipped U.S. Navy units will have one of five commonly provided chambers. They are:

1. Double-lock, 200-psig, 425-cubic-foot steel chamber (Figure 22-1).
2. Double-lock, 100-psig, 201-cubic-foot aluminum chamber. Two-lock chambers of approximately 205-cubic-foot capacity or smaller may be used as flyaway or mobile chambers (Figure 22-2).
3. Double-lock, 100-psig, 202-cubic-foot steel chamber (ARS 50 class) (Figure 22-3 and Figure 22-4).
4. Transportable Recompression Chamber System (TRCS) (Figure 22-5).
5. Fly Away Recompression Chamber (Figure 22-8, Figure 22-9, and Figure 22-10).

- 22-2.1 Basic Requirements.** Double-lock chambers are used because they permit tending personnel and supplies to enter and leave the chamber during treatment. Where stated:

- **On-site chamber** is defined as a certified and ready chamber accessible within 30 minutes of the dive site by available transportation.
- **On-station chamber** is defined as a certified and ready chamber at the dive site.
- **Emergency chamber** is defined as the closest recompression chamber available. A non-certified chamber may be used if the diving supervisor is of the opinion that it is safe to use.

Double-Lock Steel Recompression Chamber

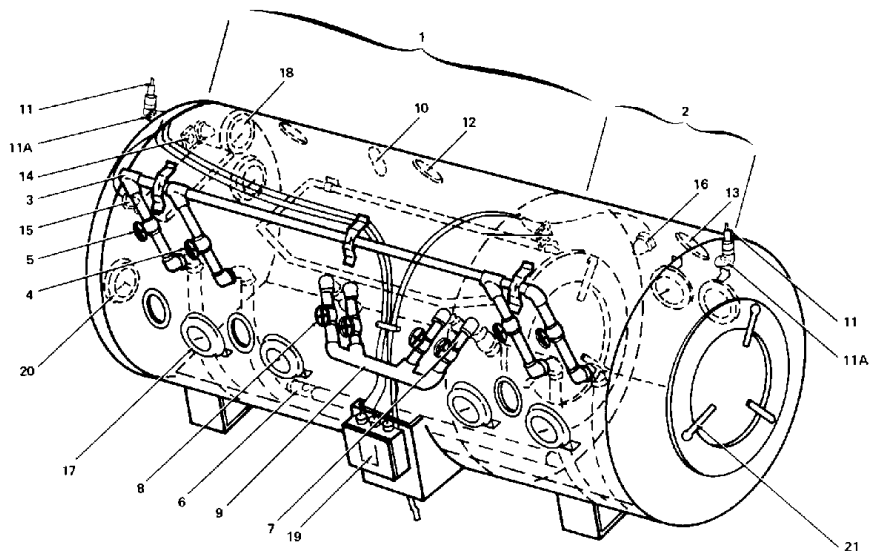


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|--|--|
| 1. Inner Lock | 11. Medical Lock 18-Inch Diameter |
| 2. Outer Lock | 12. View Port – Inner Lock (4) |
| 3. Air Supply – Two-Valve | 13. View Port – Outer Lock (2) |
| 4. Air Supply – One-Valve | 14. Lights – Inner Lock 40 Watt (4) |
| 5. Main Lock Pressure Equalizing Valve | 15. Lights – Outer Lock 40 Watt |
| 6. Exhaust – Two-Valve | 16. Transmitter/Receiver |
| 7. Exhaust – One-Valve | 17. Berth – 2'6" × 6'6" |
| 8. Oxygen Manifold | 18. Bench |
| 9. Relief Gag Valve (1 each lock) | 19. Pressure Gauge – Outside (2 each lock) |
| 10. Relief Valve – 110 psig | 20. Pressure Gauge – Inside (1 each lock) |

Original Design Pressure – 200 psig
 Original Hydrostatic Test Pressure – 400 psig
 Maximum Operating Pressure – 100 psig

Figure 22-1. Double Lock Steel Recompression Chamber.

Double-Lock Aluminum Recompression Chamber



- | | |
|---|--|
| 1. Inner Lock | 11A. Gag Valve |
| 2. Outer Lock | 12. View Port – Inner Lock (4) |
| 3. Air Supply Connection | 13. View Port – Outer Lock (2) |
| 4. Air Supply – Two-Valve | 14. Transmitter/Receiver (2) |
| 5. Air Supply – One-Valve | 15. Lights – Inner Lock 40 Watt (4) |
| 6. Inner Lock Pressure Equalizing Valve | 16. Lights – Outer Lock 40 Watt |
| 7. Exhaust – Two-Valve | 17. Pressure Gauge – Outside (2 each lock) |
| 8. Exhaust – One-Valve | 18. Pressure Gauge – Inside (1 each lock) |
| 9. Exhaust Outlet | 19. Power Distribution Panel |
| 10. Oxygen Manifold | 20. Clock (optional) |
| 11. Relief Valve – 110 psig | 21. Door Dogs |

Design Pressure – 100 psig

Original Hydrostatic Test Pressure – 200 psig

Volume – Inner Lock = 136 cubic feet

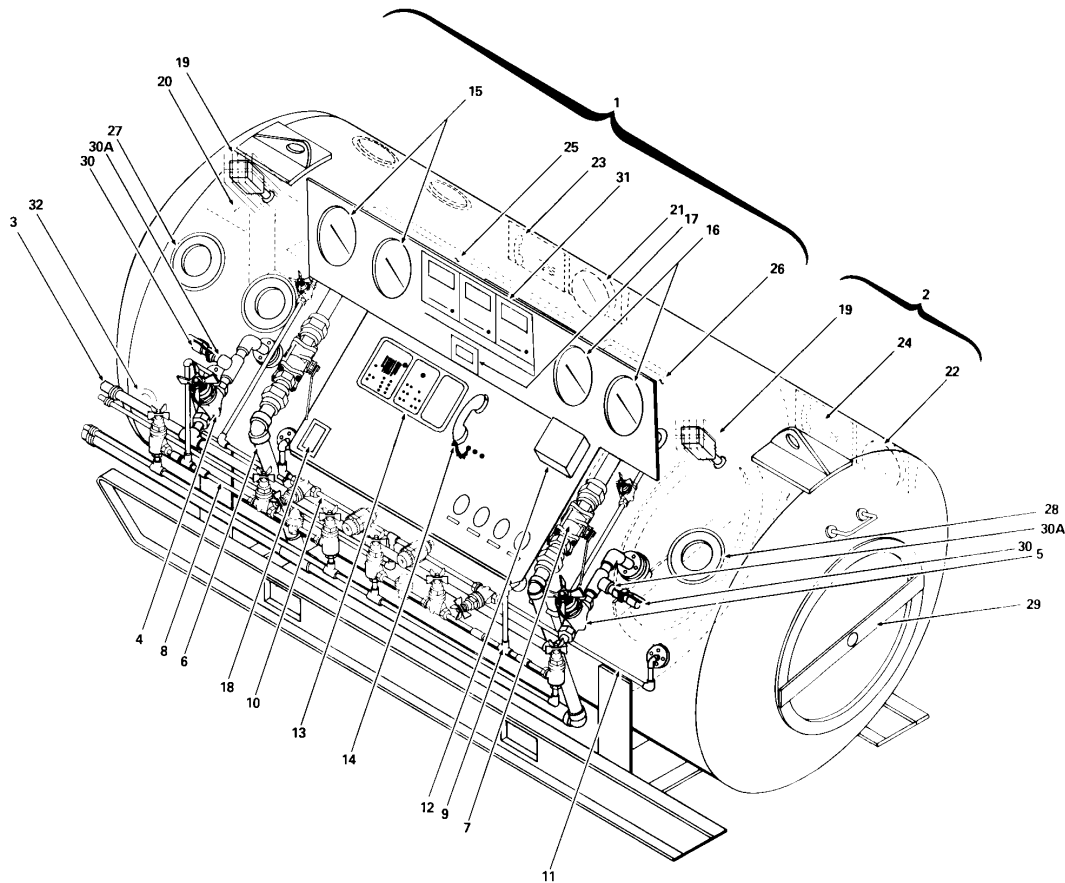
– Outer Lock = 65 cubic feet

– Total = 201 cubic feet

Principal locations – Repair/salvage ships and most shore-based facilities.

Figure 22-2. Double-Lock Aluminum Recompression Chamber.

ARS 50 Class Double-Lock Recompression Chamber



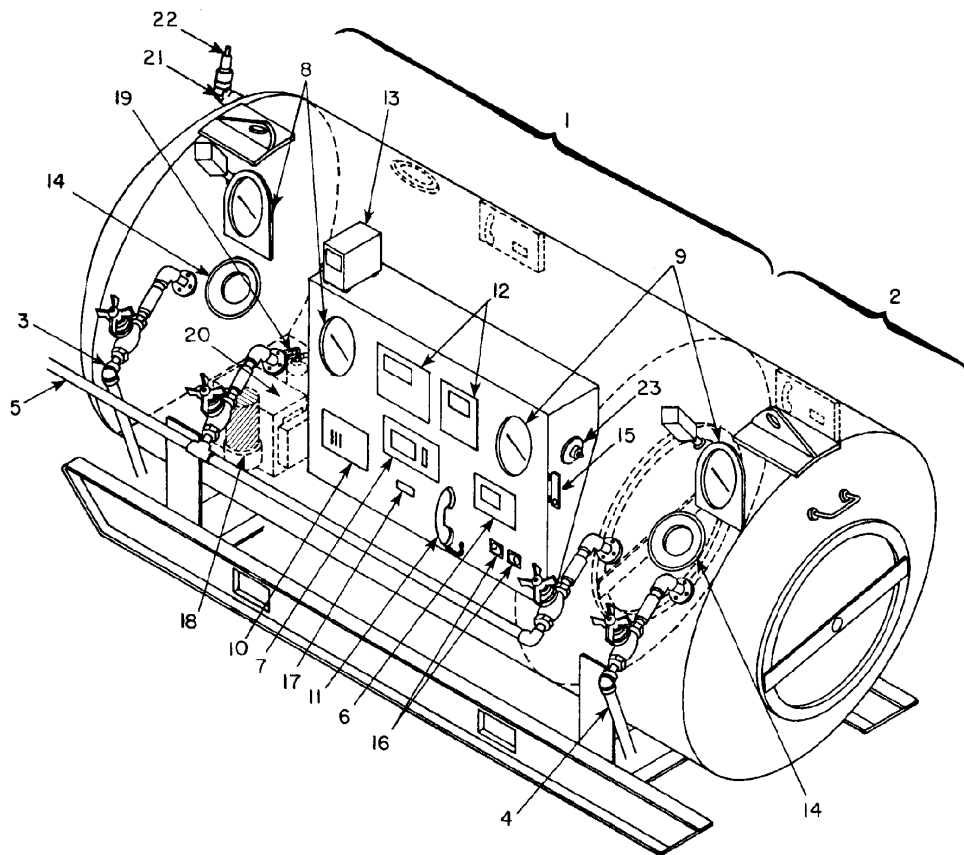
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|--|---------------------------------|
| 1. Inner Lock | 18. Ground Fault Interrupter |
| 2. Outer Lock | 19. Pipe Light Assembly |
| 3. Air Supply Connection | 20. Chiller and Scrubber Panel |
| 4. Air Supply – Inner Lock | 23. Inner Lock Comm Panel |
| 5. Air Supply – Outer Lock | 24. Outer Lock Comm Panel |
| 6. Exhaust – Inner Lock | 25. Bunk Main |
| 7. Exhaust – Outer Lock | 26. Bunk Extension |
| 8. BIBS Supply – Inner Lock | 27. View Ports – Inner Lock (4) |
| 9. BIBS Supply – Outer Lock | 28. View Ports – Outer Lock (2) |
| 10. BIBS Exhaust – Inner Lock | 29. Strongback |
| 11. BIBS Exhaust – Outer Lock | 30. Relief Valve – 100 psig |
| 12. Oxygen Analyzer | 30A. Gag Valve |
| 13. Communications | 31. Pipe Light Controls |
| 14. Sound-Powered Phones | 32. Chiller/Scrubber Penetrator |
| 15. External Depth Gauges – Inner Lock (2) | |
| 16. External Depth Gauges – Outer Lock (2) | |
| 17. Telethermometer | |

Design Pressure – 100 psig
 Original Hydrostatic Pressure – 150 psig
 Principal Locations – ARS-50 Class Salvage Ships

Volume – Inner Lock = 134 cubic feet
 – Outer Lock = 68 cubic feet
 – Total = 202 cubic feet

Figure 22-3. ARS 50 Class Double Lock Recompression Chamber.

Fleet Modernized Double-Lock Recompression Chamber



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

Figure 22-4. Fleet Modernized Double-Lock Recompression Chamber.

22-2.1.1 **Chamber Volume.** Navy chambers rated at the same pressure do not all have the same physical dimensions, with the exception of the aluminum chambers, ARS 50 class chambers, TRCS, and FARCC. Consequently, internal volumes of steel chambers are not standard and must be calculated for each chamber. Chamber volume is normally provided with the chamber.

The basic components of a recompression chamber are much the same from one model to another. They must be able to impose and maintain a pressure equivalent to a depth of 165 fsw (6 atmospheres absolute). The piping and valving on some chambers is arranged to permit control of the air supply and the exhaust from either the inside or the outside of the chamber. Controls on the outside must be able to override the inside controls in the event of a problem inside the chamber.

The usual method for providing this dual-control capability is through the use of two separate systems. The first, consisting of a supply line and an exhaust line, can only be controlled by valves that are outside of the chamber. The second air supply/exhaust system has a double set of valves, one inside and one outside the chamber. This arrangement permits the tender to regulate descent or ascent from within the chamber, but always subject to final control by outside personnel.

22-2.2 **Modernized Chamber.** Modernized chambers (Figure 22-4) have carbon dioxide and oxygen monitors, a CO₂ scrubber system, a Built-In Breathing System (BIBS), and an oxygen dump system which together reduce the ventilation requirements. These chambers also include a chamber environment control system that regulates humidity and temperature.

22-2.3 **Transportable Recompression Chamber System (TRCS).** In addition to the chambers described above, a Transportable Recompression Chamber System (TRCS) is currently in fleet use (Figure 22-5). The TRCS consists of two pressure chambers. One is a conical-shaped chamber (Figure 22-6) called the Transportable Recompression Chamber, and the other is a cylindrical shaped vessel (Figure 22-7) called the Transfer Lock (TL). The two chambers are capable of being connected by means of a freely rotating NATO female flange coupling.

When a recompression chamber is required on site per Figure 6-14, or surface decompression dives are planned, the full TRCS system (including both TRC and TL) shall be on site.

When a recompression chamber is not required on site per Figure 6-14, the inner lock (TRC) may be used for emergency recompression treatment.

22-2.4 **Fly Away Recompression Chamber (FARCC).** This chamber system consists of a 60-inch double lock modernized chamber in a 20' x 8' x 8' milvan (Figure 22-8 and Figure 22-9). The Fly Away Recompression Chamber (FARCC) also includes a life support skid (Figure 22-10). In addition, a stand-alone generator is provided for remote site power requirements.

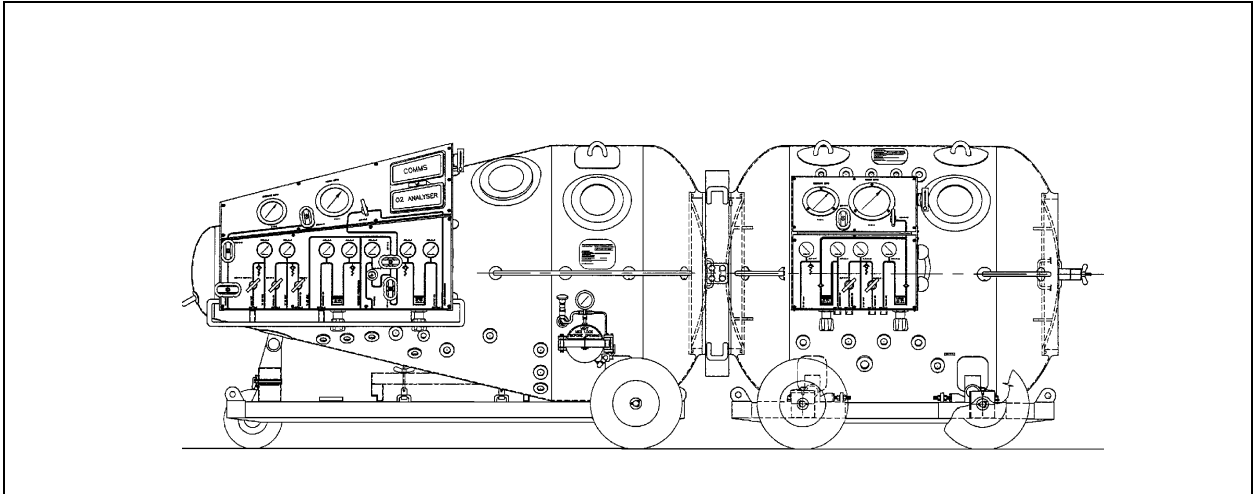


Figure 22-5. Transportable Recompression Chamber System (TRCS).

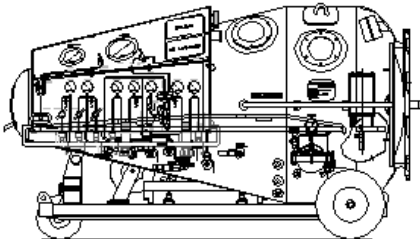
	Height	52" with wheel, 48" without wheels	
	Width	50.7"	
	Weight	1,268 lbs.	
	Internal Volume	45 cu. ft.	
	Door Opening	26"	
	View Ports	3 @ 6" dia. Clear Opening	
	Medical Lock	5.75" dia. x 11.8" long	
	Mating Flange	Male per NATO STANG 1079	
	Life Support Scrubber	Air driven, replaceable scrubber, canister fits in Med Lock	
	BIBS	2 masks – oxygen and air supply (with capability for N ₂ O ₂ or HeO ₂) – overboard dump	
Design Pressure	110 psig	Atmospheric Monitoring	Oxygen and Carbon Dioxide Analyzer
Design Temperature	0-125°F	Gas Supply	Primary and secondary air and O ₂
Length	95.7"	Communications	Battery-powered speaker/headset phone
		Furnishing	Patient litter, attendants seat

Figure 22-6. Transportable Recompression Chamber (TRC).

22-2.5 Standard Features. Recompression chambers must be equipped with a means for delivering breathing oxygen to the personnel in the chamber. The inner lock should be provided with connections for demand-type oxygen inhalators. Oxygen can be furnished through a high-pressure manifold connected with supply cylinders outside the chamber.

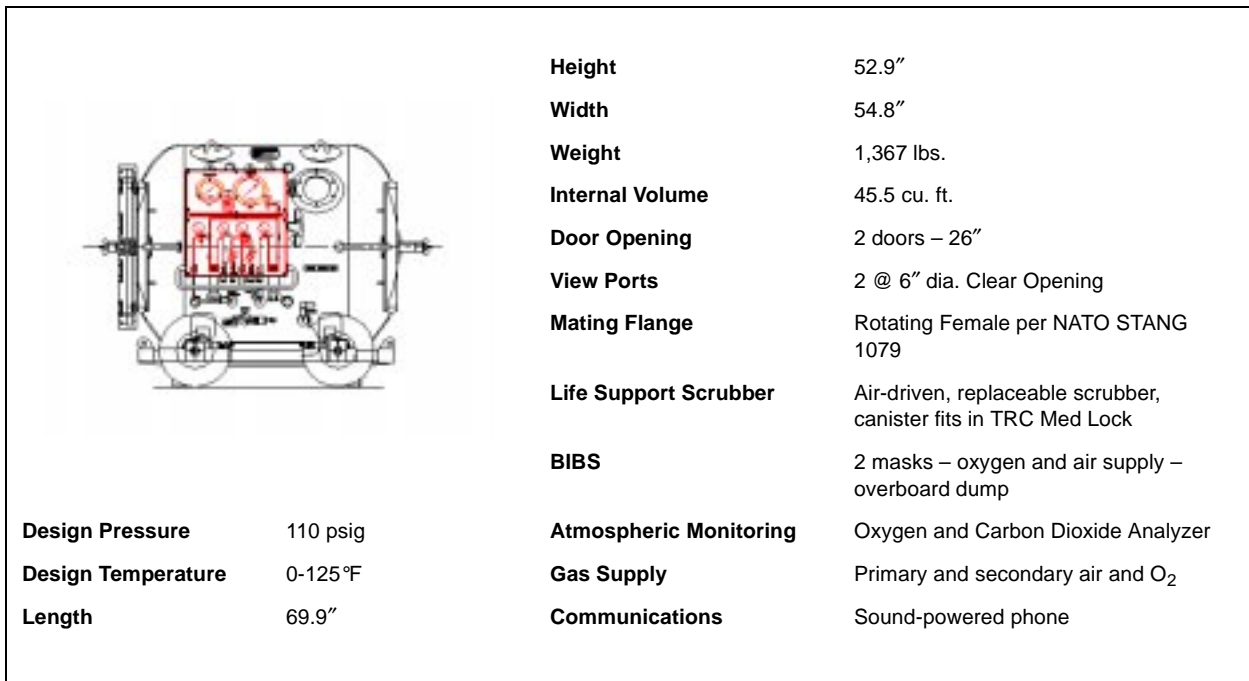


Figure 22-7. Transfer Lock (TL).

22-2.5.1 **Labeling.** All lines should be identified and labeled to indicate function, content and direction of flow. The color coding in Table 22-1 should be used.

Table 22-1. Recompression Chamber Line Guide.

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

- 22-2.5.2 **Inlet and Exhaust Ports.** Optimum chamber ventilation requires separation of the inlet and exhaust ports within the chamber. Exhaust ports must be provided with a guard device to prevent accidental injury when they are open.
- 22-2.5.3 **Pressure Gauges.** Chambers must be fitted with appropriate pressure gauges. These gauges, marked to read in feet of seawater (fsw), must be calibrated or compared as described in the applicable Planned Maintenance System (PMS) to ensure accuracy in accordance with the instructions in Chapter 4.
- 22-2.5.4 **Relief Valves.** Recompression chambers should be equipped with pressure relief valves in each manned lock. Chambers that do not have latches (dogs) on the doors are not required to have a relief valve on the outer lock. The relief valves shall be set in accordance with PMS. In addition, all chambers shall be equipped with a gag valve, located between the chamber pressure hull and each relief valve. This gag valve shall be a quick acting, ball-type valve, sized to be compatible with the relief valve and its supply piping. The gag valve shall be safety wired in the open position

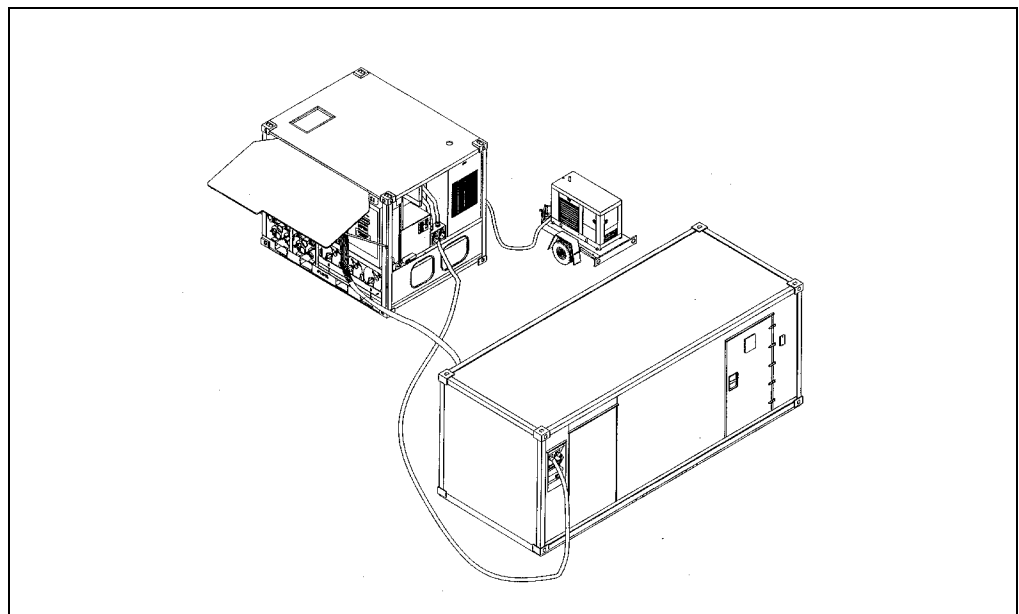


Figure 22-8. Fly Away Recompression Chamber (FARCC).

- 22-2.5.5 **Communications System.** Chamber communications are provided through a diver's intercommunication system, with the dual microphone/speaker unit in the chamber and the surface unit outside. The communication system should be arranged so that personnel inside the chamber need not interrupt their activities to operate the system. The backup communications system may be provided by a set of standard sound-powered telephones. The press-to-talk button on the set inside the chamber can be taped down, thus keeping the circuit open.
- 22-2.5.6 **Lighting Fixtures.** Consideration should be given to installation of a low-level lighting fixture (on a separate circuit), which can be used to relieve the patient of

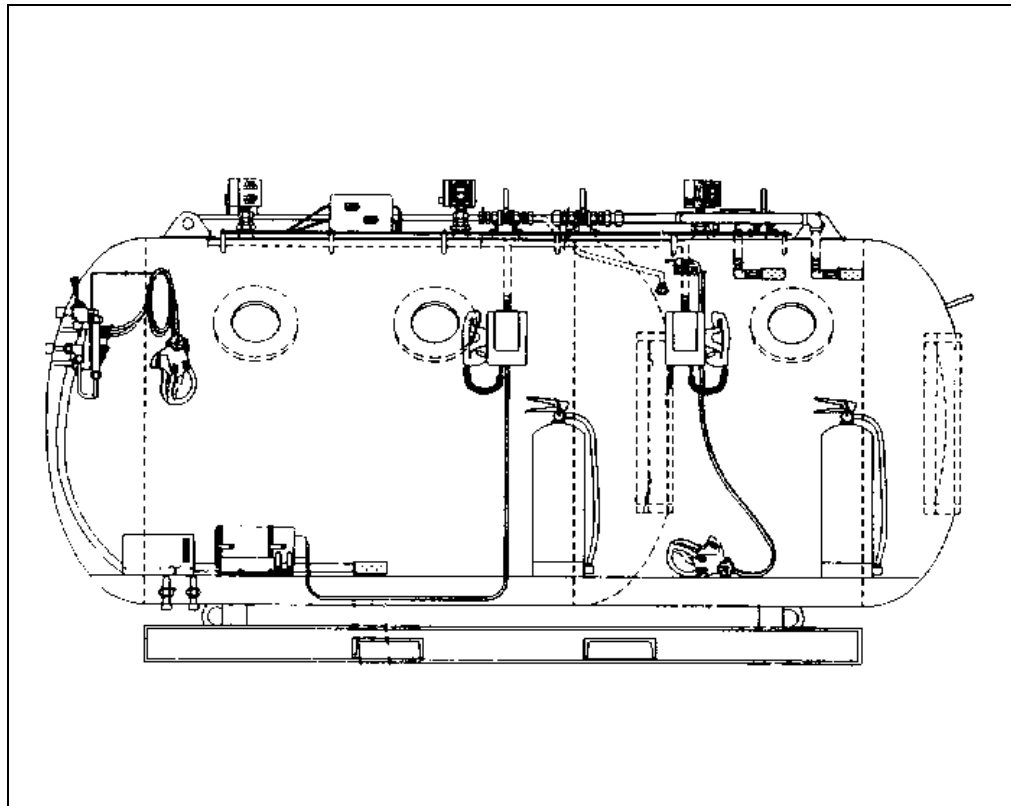


Figure 22-9. Fly Away Recompression Chamber.

the heat and glare of the main lights. Emergency lights for both locks and an external control station are mandatory. No electrical equipment, other than that authorized within the scope of certification or as listed in the NAVSEA Authorized for Navy Use (ANU) List, is allowed inside the chamber. Because of the possibility of fire or explosion when working in an oxygen or compressed air atmosphere, all electrical wiring and equipment used in a chamber shall meet required specifications.

22-3 STATE OF READINESS

Since a recompression chamber is emergency equipment, it must be kept in a state of readiness. The chamber shall be well maintained and equipped with all necessary accessory equipment. A chamber is not to be used as a storage compartment. The chamber and the air and oxygen supply systems shall be checked prior to each use with the Pre-dive Checklist and in accordance with PMS instructions. All diving personnel shall be trained in the operation of the recompression chamber equipment and should be able to perform any task required during treatment.

22-4 GAS SUPPLY

A recompression chamber system must have a primary and a secondary air supply system that satisfy the following requirements.

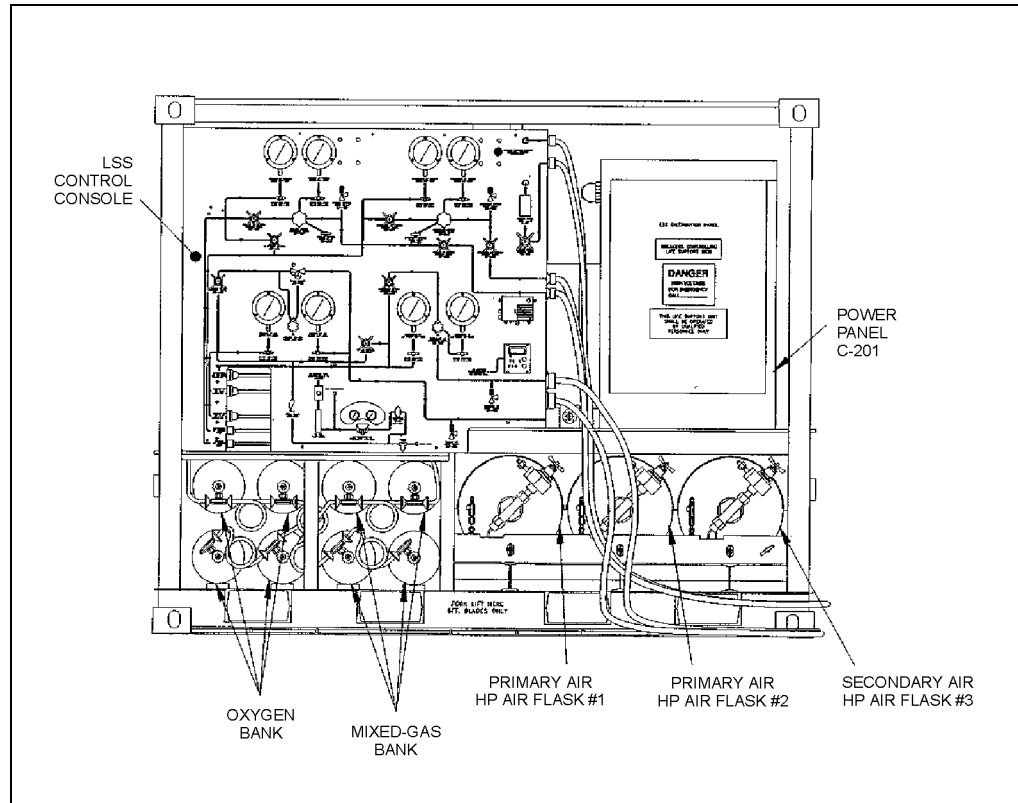


Figure 22-10. Fly Away Recompression Chamber Life Support Skid.

- **Primary.** Sufficient air to pressurize the inner lock once to 165 feet and the outer lock twice to 165 feet and ventilate during one Treatment Table 4 (Chapter 21).
- **Secondary.** Sufficient air to pressurize the inner and outer locks once to 165 feet and ventilate for one hour at 70.4 scfm.

22-4.1 Capacity. Either system may consist of air banks and/or a suitable compressor. The primary recompression chamber support system must be capable of pressurizing the inner lock to a depth of 165 feet. The required total capacity is calculated as follows.

- **Primary System Capacity:**

$$C_p = (5 \times V_{il}) + (5 \times V_{ol}) + 4,224$$

Where:

- | | | |
|----------|---|---|
| C_p | = | minimum capacity of primary system in scf |
| V_{il} | = | volume of inner lock in scf |
| V_{ol} | = | volume of outer lock in scf |
| 5 | = | atmospheres equivalent to 165 fsw |
| 10 | = | twice 5 atmospheres |

45,390 = total air in scf required to ventilate during a Table 4 Treatment

■ Secondary System Capacity:

$$C_s = (5 \times V_{il}) + (5 \times V_{ol}) + 4,224$$

Where:

C_s	=	minimum capacity of secondary system in scf
V_{il}	=	volume of inner lock
V_{ol}	=	volume of outer lock
5	=	atmospheres equivalent to 165 fsw
4224	=	air in scf required for maximum ventilation rate of 70.4 scfm for one hour (60 min)

22-5 OPERATION

22-5.1 Prediving Checklist. To ensure each item is operational and ready for use, perform the equipment checks listed in the Recompression Chamber Prediving Checklist, Figure 22-11a.

22-5.2 Safety Precautions.

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

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

Figure 22-11a. Recompression Chamber Prediving Checklist (sheet 1 of 2).

RECOMPRESSION CHAMBER PREDIVE CHECKLIST	
Equipment	Initials
Electrical System	
Lights	
Carbon dioxide analyzer calibrated	
Oxygen analyzer calibrated	
Temperature indicator calibrated	
Carbon dioxide scrubber operational	
Chamber conditioning unit operational	
Direct Current (DC) power supply	
Ground Fault Interrupter (GFI)	
Communication System	
Primary system tested	
Secondary system tested	
Fire Prevention System	
Tank pressurized for chambers with installed fire suppression systems	
Combustible material in metal enclosure	
Fire-retardant clothing worn by all chamber occupants	
Fire-resistant mattresses and blankets in chamber	
Miscellaneous	
Inside Chamber:	CO ₂ -absorbent canister with fresh absorbent installed
	Urinal
	Primary medical kit
	Ear protection sound attenuators/aural protectors (1 set per person)
Outside Chamber:	Heater/chiller unit
	Stopwatches for recompression treatment time, decompression time, personnel leaving chamber time, and cumulative time
	Fresh CO ₂ scrubber canister
	<i>U.S. Navy Diving Manual</i> , Volume 5
	Ventilation bill
	Chamber log
	Operating Procedures (OPs) and Emergency Procedures (EPs)
	Secondary medical kit
	Bedpan (to be locked in as required)

Figure 22-11b. Recompression Chamber Prediving Checklist (sheet 2 of 2).

22-5.3 General Operating Procedures.

1. Ensure completion of Pre-dive Checklist.
2. Diver and tender enter the chamber together.
3. Diver sits in an uncramped position.
4. Tender closes and dogs (if so equipped) the inner lock door.
5. Pressurize the chamber, at the rate and to the depth specified in the appropriate decompression or recompression table.
6. As soon as a seal is obtained or upon reaching depth, tender releases the dogs (if so equipped).
7. Ventilate chamber according to specified rates and energize CO₂ scrubber and chamber conditioning system.
8. Ensure proper decompression of all personnel.
9. Ensure completion of Post-dive Checklist.

22-5.3.1 **Tender Change-Out.** During extensive treatments, medical personnel may prefer to lock-in to examine the patient and then lock-out, rather than remain inside throughout the treatment. Inside tenders may tire and need relief.

22-5.3.2 **Lock-In Operations.** Personnel entering the chamber go into the outer lock and close and dog the door (if applicable). The outer lock should be pressurized at a rate controlled by their ability to equalize, but not to exceed 75 feet per minute. The outside tender shall record the time pressurization begins to determine the decompression schedule for the occupants when they are ready to leave the chamber. When the pressure levels in the outer and inner locks are equal, the inside door (which was undogged at the beginning of the treatment) should open.

22-5.3.3 **Lock-Out Operations.** To exit the chamber, the personnel again enter the outer lock and the inside tender closes and dogs the inner door (if so equipped). When ready to ascend, the Diving Supervisor is notified and the required decompression schedule is selected and executed. Constant communications are maintained with the inside tender to ensure that a seal has been made on the inner door. Outer lock depth is controlled throughout decompression by the outside tender.

22-5.3.4 **Gag Valves.** The actuating lever of the chamber gag valves shall be maintained in the open position at all times, during both normal chamber operations and when the chamber is secured. The gag valves must be closed only in the event of relief valve failure during chamber operation. Valves are to be lock-wired in the open position with light wire that can be easily broken when required. A WARNING plate, bearing the inscription shown below, shall be affixed to the chamber in the vicinity of each gag valve and shall be readily viewable by operating personnel.

The WARNING plates shall measure approximately 4 inches by 6 inches and read as follows:

<p>WARNING The gag valve must remain open at all times. Close only if relief valve fails.</p>
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22-5.4 Ventilation. The basic rules for ventilation are presented below. These rules permit rapid computation of the cubic feet of air per minute (acfm) required under different conditions as measured at chamber pressure (the rules are designed to ensure that the effective concentration of carbon dioxide will not exceed 1.5 percent (11.4 mmHg) and that when oxygen is being used, the percentage of oxygen in the chamber will not exceed 25 percent).

1. When air is breathed, provide 2 cubic feet per minute (acfm) for each diver at rest and 4 cubic feet per minute (acfm) for each diver who is not at rest (i.e., a tender actively taking care of a patient).
2. When oxygen is breathed from the built-in breathing system (BIBS), provide 12.5 acfm for a diver at rest and 25 acfm for a diver who is not at rest. When these ventilation rates are used, no additional ventilation is required for personnel breathing air. These ventilation rates apply only to the number of people breathing oxygen and are used only when no BIBS dump system is installed.
3. If ventilation must be interrupted for any reason, the time should not exceed 5 minutes in any 30-minute period. When ventilation is resumed, twice the volume of ventilation should be used for the time of interruption and then the basic ventilation rate should be used again.
4. If a BIBS dump system is used for oxygen breathing, the ventilation rate for air breathing may be used.
5. If portable or installed oxygen and carbon dioxide monitoring systems are available, ventilation may be adjusted to maintain the oxygen level below 25 percent by volume and the carbon dioxide level below 1.5 percent surface equivalent (sev).

22-5.4.1 Chamber Ventilation Bill. Knowing how much air must be used does not solve the ventilation problem unless there is some way to determine the volume of air actually being used for ventilation. The standard procedure is to open the exhaust valve a given number of turns (or fraction of a turn), which will provide a certain number of cubic feet of ventilation per minute at a specific chamber depth, and to use the supply valve to maintain a constant chamber depth during the ventilation period. Determination of valve settings required for different amounts of ventilation at different depths is accomplished as follows.

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

1. Mark the valve handle position so that it is possible to determine accurately the number of turns and fractions of turns.
2. Check the basic ventilation rules above against probable situations to determine the rates of ventilation at various depths (chamber pressure) that may be needed. If the air supply is ample, determination of ventilation rates for a few depths (30, 60, 100, and 165 feet) may be sufficient. It will be convenient to know the valve settings for rates such as 6, 12.5, 25, or 37.5 cubic feet per minute (acfm).
3. Determine the necessary valve settings for the selected flows and depths by using a stopwatch and the chamber as a measuring vessel.
 - a. Calculate how long it will take to change the chamber pressure by 10 feet if the exhaust valve lets air escape at the desired rate close to the depth in question. Use the following formula.

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

Where:

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

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

1. List values from example:

- T = unknown
V = 425 cf
R = 6 acfm
P = 10 fsw
D = 165 fsw

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

$$\begin{aligned}
 T &= \frac{425 \times 60 \times 10}{6(165 + 33)} \\
 &= 215 \text{ seconds} \\
 T &= \frac{215 \text{ seconds}}{60 \text{ seconds / minute}} \\
 &= 3.6 \text{ minutes}
 \end{aligned}$$

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

22-5.4.2 **Notes on Chamber Ventilation.**

- The basic ventilation rules are not intended to limit ventilation. Generally, if air is reasonably plentiful, more air than specified should be used for comfort. This increase is desirable because it also further lowers the concentrations of carbon dioxide and oxygen.
- There is seldom any danger of having too little oxygen in the chamber. Even with no ventilation and a high carbon dioxide level, the oxygen present would be ample for long periods of time.
- These rules assume that there is good circulation of air in the chamber during ventilation. If circulation is poor, the rules may be inadequate. Locating the inlet near one end of the chamber and the outlet near the other end improves ventilation.
- Coming up to the next stop reduces the standard cubic feet of gas in the chamber and proportionally reduces the quantity (scfm) of air required for ventilation.
- Continuous ventilation is the most efficient method of ventilation in terms of the amount of air required. However, it has the disadvantage of exposing the divers in the chamber to continuous noise. At the very high ventilation rates required for oxygen breathing, this noise can reach the level at which hearing loss becomes a hazard to the divers in the chamber. If high sound levels do occur, especially during exceptionally high ventilation rates, the chamber occupants must wear aural protectors (available as a stock item). A small hole should be drilled into the central cavity of the protector so that they do not produce a seal which can cause ear squeeze.

- The size of the chamber does not influence the rate (acfm) of air required for ventilation.
- Increasing depth increases the actual mass of air required for ventilation; but when the amount of air is expressed in volumes as measured at chamber pressure, increasing depth does not change the number of actual cubic feet (acfm) required.
- If high-pressure air banks are being used for the chamber supply, pressure changes in the cylinders can be used to check the amount of ventilation being provided.

22-6 CHAMBER MAINTENANCE

22-6.1 Postdive Checklist. To ensure equipment receives proper postdive maintenance and is returned to operational readiness, perform the equipment checks listed in the Recompression Chamber Postdive Checklist, Figure 22-12a.

22-6.2 Scheduled Maintenance. Proper care of a recompression chamber requires both routine and periodic maintenance. Every USN recompression chamber (with the exception of the TRCS) shall be pressure tested upon installation, at 2-year intervals thereafter, after a major overhaul or repair, and each time it is moved. This test shall be conducted in accordance with the pressure test for USN recompression chambers (Figure 22-13a) contained in this chapter. The completed test form shall be retained until retest is conducted. Chamber relief valves shall be tested in accordance with the Planned Maintenance System to verify setting. Each tested relief valve shall be tagged to indicate the valve set pressure, date of test, and testing activity. After every use or once a month, whichever comes first, the chamber shall receive routine maintenance in accordance with the Postdive Checklist. At this time, minor repairs shall be made and used supplies shall be restocked.

22-6.2.1 Inspections. At the discretion of the activity, but at least once a year, the chamber shall be inspected, both inside and outside. Any deposits of grease, dust, or other dirt shall be removed and, on steel chambers, the affected areas repainted.

22-6.2.2 Corrosion. Corrosion is removed best by hand or by using a scraper, being careful not to gouge or otherwise damage the base metal. The corroded area and a small area around it should then be cleaned to remove any remaining paint and/or corrosion.

22-6.2.3 Painting Steel Chambers. Steel chambers shall be painted in accordance with approved NAVSEA procedures. The following paint shall be utilized on steel chambers:

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

RECOMPRESSION CHAMBER POSTDIVE CHECKLIST	
Equipment	Initials
Air Supply	
All valves closed	
Air banks recharged, gauged, and pressure recorded	
Compressors fueled and maintained per technical manual/PMS requirements	
View Ports and Doors	
View-ports checked for damage; replaced as necessary	
Door seals checked, replaced as necessary	
Door seals lightly lubricated with approved lubricant	
Door dogs and dogging mechanism checked for proper operation and shaft seals for tightness	
Chamber	
Inside wiped clean with Nonionic Detergent (NID) and warm fresh water	
All but necessary support items removed from chamber	
Blankets cleaned and replaced	
All flammable material in chamber encased in fire-resistant containers	
Primary medical kit restocked as required	
Chamber aired out	
Outer door closed	
CO ₂ canister packed	
Deckplates lifted, area below deckplates cleaned, deckplates reinstalled	
Support Items	
Stopwatches checked and reset	
<i>U.S. Navy Diving Manual</i> , Operating Procedures (OPs), Emergency Procedures (EPs), ventilation bill and pencil available at control desk	
Secondary medical kit restocked as required and stowed	
Clothing cleaned and stowed	
All entries made in chamber log book	
Chamber log book stowed	

Figure 22-12a. Recompression Chamber Postdive Checklist (sheet 1 of 2).

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

Figure 22-12b. Recompression Chamber Postdive Checklist (sheet 2 of 2).

- Outside:

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

22-6.2.4 **Recompression Chamber Paint Process Instruction.** Painting shall be kept to an absolute minimum. Only the coats prescribed above are to be applied. Naval Sea Systems Command will issue a Recompression Chamber Paint Process Instruction (NAVSEA-00C3-PI-001) on request.

22-6.2.5 **Aluminum Chambers.** Only steel chambers are painted. Aluminum chambers are normally a dull, uneven gray color and corrosion can be easily recognized. Aluminum chambers will not be painted.

22-6.2.6 **Fire Hazard Prevention.** The greatest single hazard in the use of a recompression chamber is from explosive fire. Fire may spread two to six times faster in a pressurized chamber than at atmospheric conditions because of the high partial

NOTE

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

A pressure test shall be conducted on every USN recompression chamber (except TRCS):

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

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

The test is conducted as follows:

1. Pressurize the innermost lock to 100 fsw (45 psig). Using soapy water or an equivalent solution, leak test all shell penetration fittings, view-ports, dog seals, door dogs (where applicable), valve connections, pipe joints, and shell weldments.
2. Mark all leaks. Depressurize the lock and adjust, repair, or replace components as necessary to eliminate leaks.
 - a. View-Port Leaks. Remove the view-port gasket (replace if necessary), wipe clean.

CAUTION

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

- b. Weldment Leaks. Contact appropriate NAVSEA technical authority for guidance on corrective action.
3. Repeat steps 1 and 2 until all the leaks have been eliminated.
4. Pressurize lock to 225 fsw (100 psig) and hold for 5 minutes.
5. Depressurize the lock to 165 fsw (73.4 psig). Hold for 1 hour. If pressure drops below 145 fsw (65 psig), locate and mark leaks. Depressurize chamber and repair leaks in accordance with Step 2 above and repeat this procedure until final pressure is at least 145 fsw (65 psig).
6. Repeat Steps 1 through 5 leaving the inner door open and outer door closed. Leak test only those portions of the chamber not previously tested.

Figure 22-13a. Pressure Test for USN Recompression Chambers (sheet 1 of 3).

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

Ship/Platform/Facility _____

Type of Chamber: Double-Lock Aluminum
 Double-Lock Steel
 Portable Recompression Chamber
 Other* _____

NAME PLATE DATA

Manufacturer _____

Date of Manufacture _____

Contract/Drawing No. _____

Maximum Working Pressure _____

Date of Last Pressure Test _____

Test Conducted by _____

(Name/Rank)

1. Conduct visual inspection of chamber to determine if ready for test

Chamber Satisfactory _____ Initials of Test Conductor _____

Discrepancies from fully inoperative chamber equipment:

2. Close inner door lock. With outer lock door open pressure inner lock to 100 fsw (45 psig) and verify that the following components do not leak:

(Note: If chamber has medical lock, open inner door and close and secure outer door.)

Inner lock leak checks	Initials of Test Conductor
------------------------	----------------------------

- | | | |
|------------------------------------|--------------|--|
| A. Shell penetrations and fittings | _____ | |
| | Satisfactory | |
| B. View Ports | _____ | |
| | Satisfactory | |
| C. Door Seals | _____ | |
| | Satisfactory | |
| D. Door Dog Shaft Seals | _____ | |
| | Satisfactory | |
| E. Valve Connections and Stems | _____ | |
| | Satisfactory | |
| F. Pipe Joints | _____ | |
| | Satisfactory | |
| G. Shell Welds | _____ | |
| | Satisfactory | |

3. Increase inner lock pressure to 225 fsw (100 psig) and hold for 5 minutes.

Record Test Pressure _____ Satisfactory _____

(Note: Disregard small leaks at this pressure).

Figure 22-13b. Pressure Test for USN Recompression Chambers (sheet 2 of 3).

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

4. Depressurize lock slowly to 165 fsw (73.4 psig). Secure all supply and exhaust valves and hold for one hour.

Start Time _____ Pressure 165 fsw

End Time _____ Pressure _____ fsw

If pressure drops below 145 fsw (65 psig) locate and mark leaks. Depressurize, repair, and retest inner lock.

Inner Lock Pressure drop test passed _____ Satisfactory Initials of Test Conductor.

5. Depressurize inner lock and open inner lock door. Secure in open position. Close outer door and secure.

(Note: If chamber has medical lock, close and secure inner door and open outer door.)

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

7. Outer Lock Checks Initials of Test Conductor

A. Shell penetrations and fittings _____
Satisfactory

B. View Ports _____
Satisfactory

C. Door Seals _____
Satisfactory

D. Door Dog Shaft Seals _____
Satisfactory

E. Valve Connections and Stems _____
Satisfactory

F. Pipe Joints _____
Satisfactory

G. Shell Welds _____
Satisfactory

8. Maximum Chamber Operating Pressure (100 psig) Test (5 minute hold)

Satisfactory _____ Initials of Test Conductor

9. Inner and Outer Lock Chamber Drop Test

Start Time _____ Pressure 165 fsw

End Time _____ Pressure _____ fsw

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

10. All above tests have been satisfactorily completed.

Test Director Date

Diving Officer Date

Commanding Officer Date

Figure 22-13c. Pressure Test for USN Recompression Chambers (sheet 3 of 3).

pressure of oxygen in the chamber atmosphere. The following precautions shall be taken to minimize fire hazard:

- Maintain the chamber oxygen percentage as close to 21 percent as possible and never allow oxygen percentage to exceed 25 percent.
- Remove any fittings or equipment that do not conform with the standard requirements for the electrical system or that are made of flammable materials. Permit no wooden deck gratings, benches, or shelving in the chamber.
- Use only mattresses designed for hyperbaric chambers. Use Durett Product or submarine mattress (NSN 7210-00-275-5878 or 5874). Other mattresses may cause atmospheric contamination. Mattresses should be enclosed in flame-proof covers. Use 100% cotton sheets and pillow cases. Put no more bedding in a chamber than is necessary for the comfort of the patient. Never use blankets of wool or synthetic fibers because of the possibility of sparks from static electricity.
- Keep oil and volatile materials out of the chamber. If any have been used, ensure that the chamber is thoroughly ventilated before pressurization. Do not put oil on or in any fittings or high-pressure line. If oil is spilled in the chamber or soaked into any chamber surface or equipment, it must be completely removed. If lubricants are required, use only those approved and listed in *Naval Ships Technical Manual* (NSTM) NAVSEA S9086-H7-STM-000, Chapter 262. Regularly inspect and clean air filters and accumulators in the air supply lines to protect against the introduction of oil or other vapors into the chamber. Permit no one to wear oily clothing into the chamber.
- Permit no one to carry smoking materials, matches, lighters or any flammable materials into a chamber. A WARNING sign should be posted outside the chamber. Example:

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

22-6.2.6.1 **Fire Extinguishers.** Only fire extinguishers listed on the NAVSEA Authorized for Navy Use (ANU) Lists are to be used.

22-7 DIVER CANDIDATE PRESSURE TEST

All U.S. Navy diver candidates shall be physically qualified in accordance with the *Manual of the Medical Department*, Art. 15-66. Candidates shall also pass a pressure test before they are eligible for diver training. This test may be conducted at any Navy certified recompression chamber, provided it is administered by qualified chamber personnel.

22-7.1 Candidate Requirements. The candidate must demonstrate the ability to equalize pressure in both ears to a depth of 60 fsw. The candidate shall have also passed the screening physical readiness test in accordance with MILPERSMAN 1410380, Exhibit 5.

22-7.2 Inside Tender Requirements. The inside tender(s) should be a qualified diver.

22-7.3 Procedure.

1. Candidates shall undergo a diving physical examination by a Navy Medical Officer in accordance with the *Manual of the Medical Department*, Art. 15-66, and be qualified to undergo the test.
2. The candidates and the tender enter the recompression chamber and are pressurized to 60 fsw on air, at a rate of 75 fpm or less as tolerated by the occupants.
3. If a candidate cannot complete the descent, the chamber is stopped and the candidate is placed in the outer lock for return to the surface.
4. Stay at 60 fsw for at least 10 minutes.
5. Ascend to the surface following standard air decompression procedures.
6. All candidates shall remain at the immediate chamber site for a minimum of 15 minutes and at the test facility for 1 hour. Candidates or tenders who must return to their command via air travel must proceed in accordance with Chapter 9, paragraph 9-13.

22-7.3.1 References.

- *Navy Military Personnel Manual*, Art. 1410380
- *Manual of the Medical Department*, Art. 15-66
- *SECNAVINST 12000.2A*