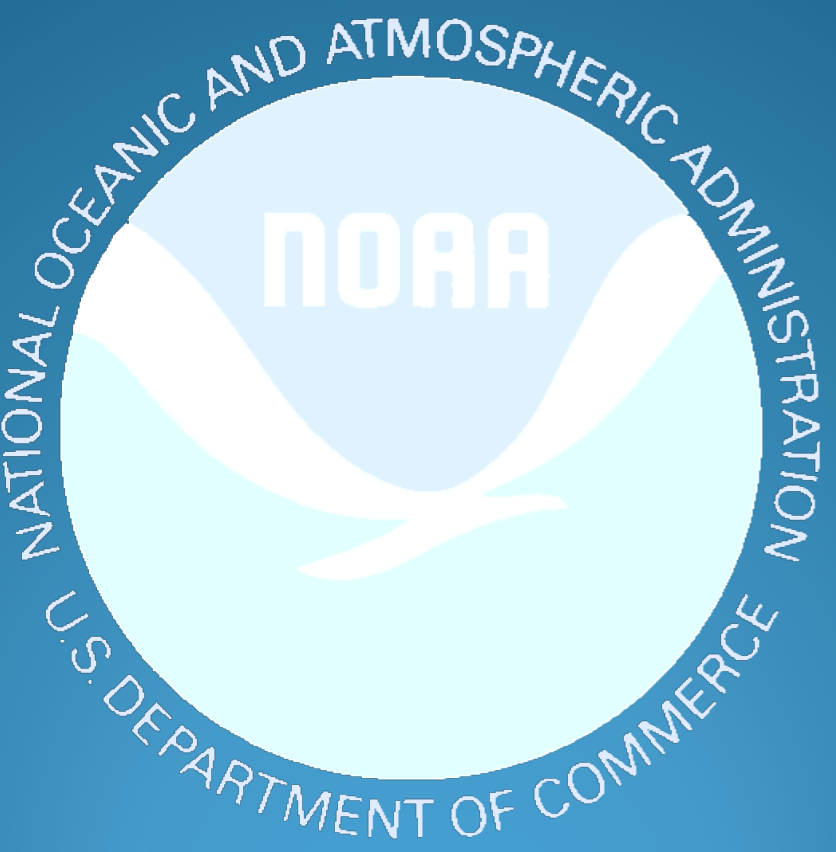
Introduction to PVHO

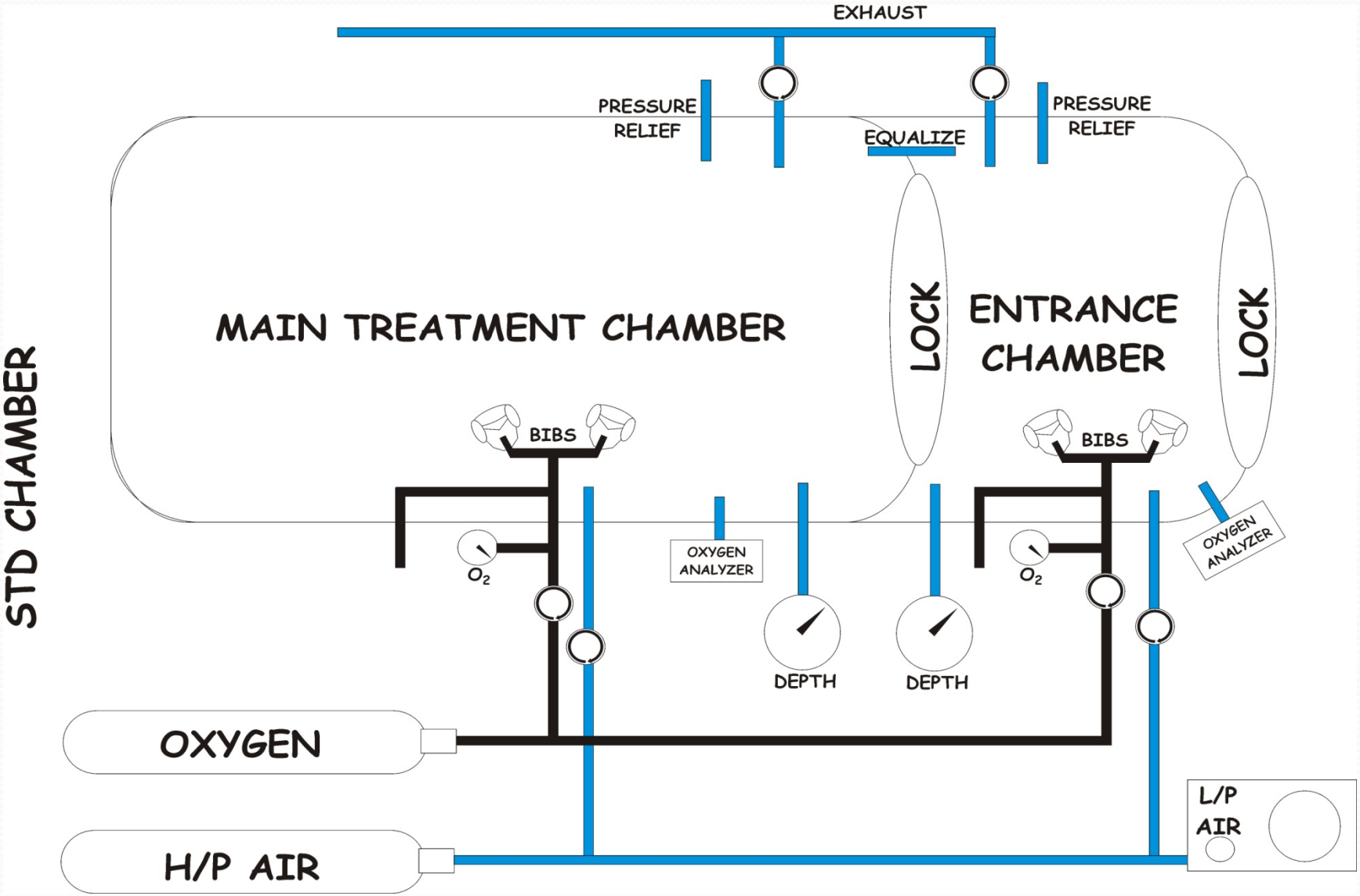


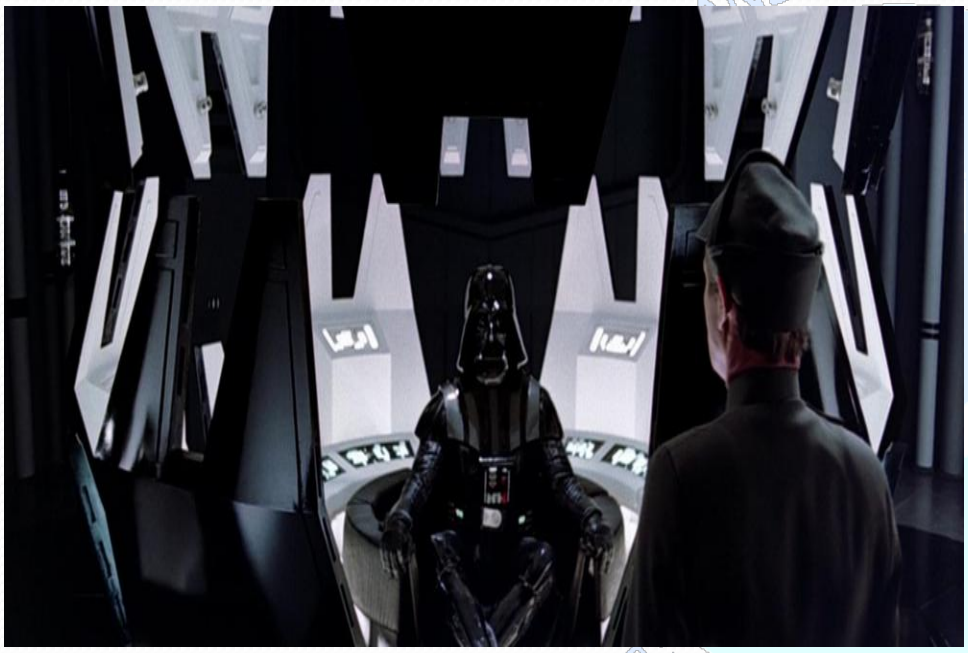
History

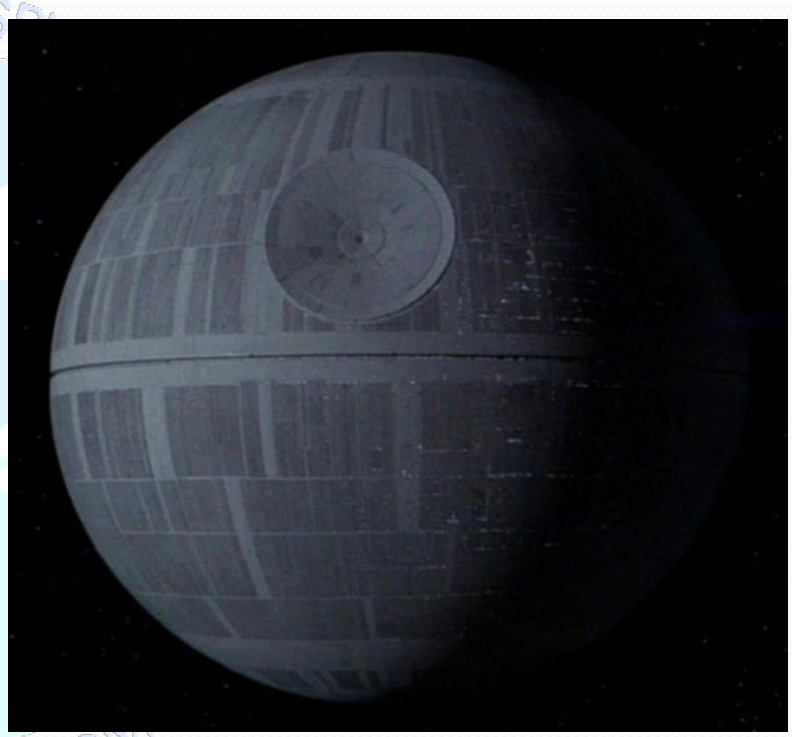
- ASME Safety Committee formed in 1974, with first publication of PVHO-1 in 1977
- Developed specific guidelines to meet areas not specifically addressed in Section VIII, Division 1 of the Boiler and Pressure Vessel Code
  - **Use of Pressure Relief Devices*
  - **Requirement for Viewports*
- Subsequent PVHO-1 revisions have addressed
  - **Design and Use of Acrylic Viewports*
  - **Integral Piping System Design Requirement*

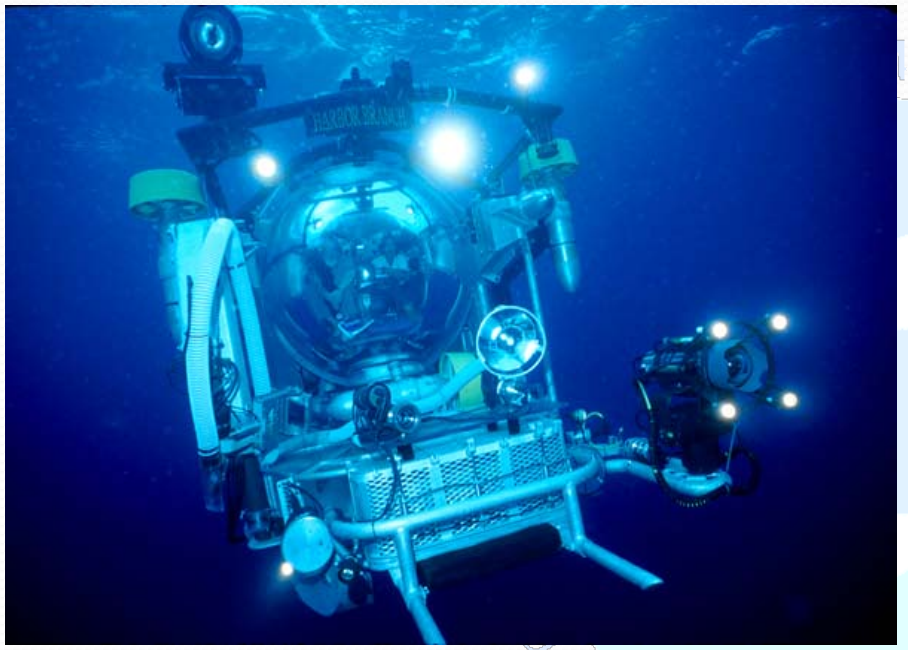
Pressure Vessels for Human Occupancy

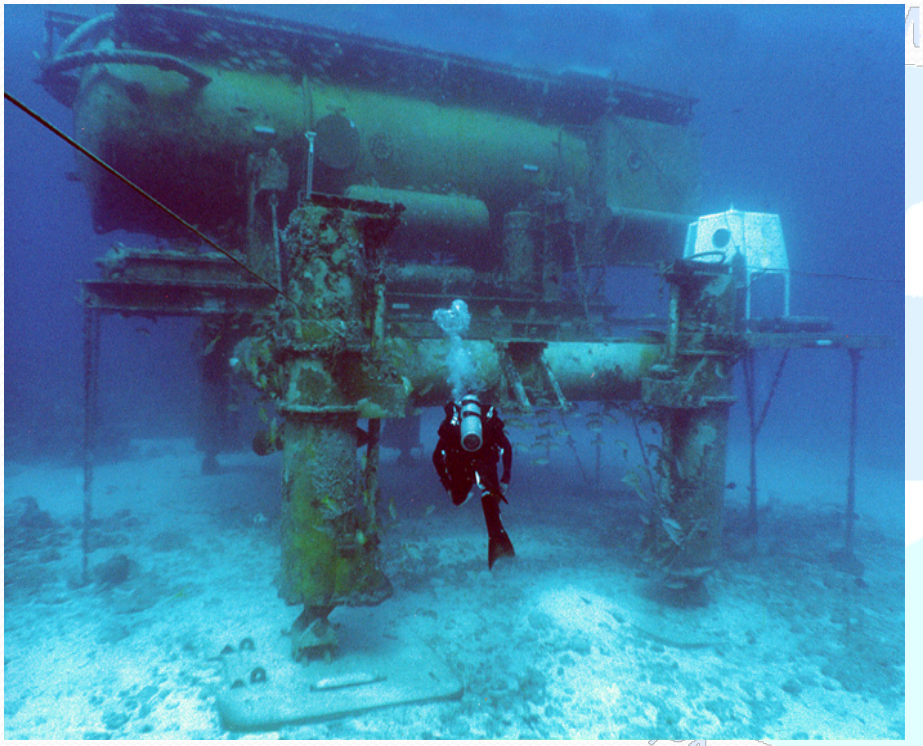
- *ASME defines PVHO as a pressure vessel that encloses a human being within its pressure boundary while it is under internal or external pressure that exceeds a 2 psi differential pressure. PVHOs include, but are not limited to, submersibles, diving bells, personnel transfer capsules, decompression chambers, recompression chambers, hyperbaric chambers, high altitude chambers, and medical hyperbaric oxygenation facilities.*


STD CHAMBER
EXHAUST
PRESSURE RELIEF
EQUALIZE
PRESSURE RELIEF
MAIN TREATMENT CHAMBER
LOCK
ENTRANCE CHAMBER
LOCK
BIBS
BIBS
O_2
O_2
OXYGEN ANALYZER
OXYGEN ANALYZER
DEPTH
DEPTH
OXYGEN
H/P AIR
L/P AIR

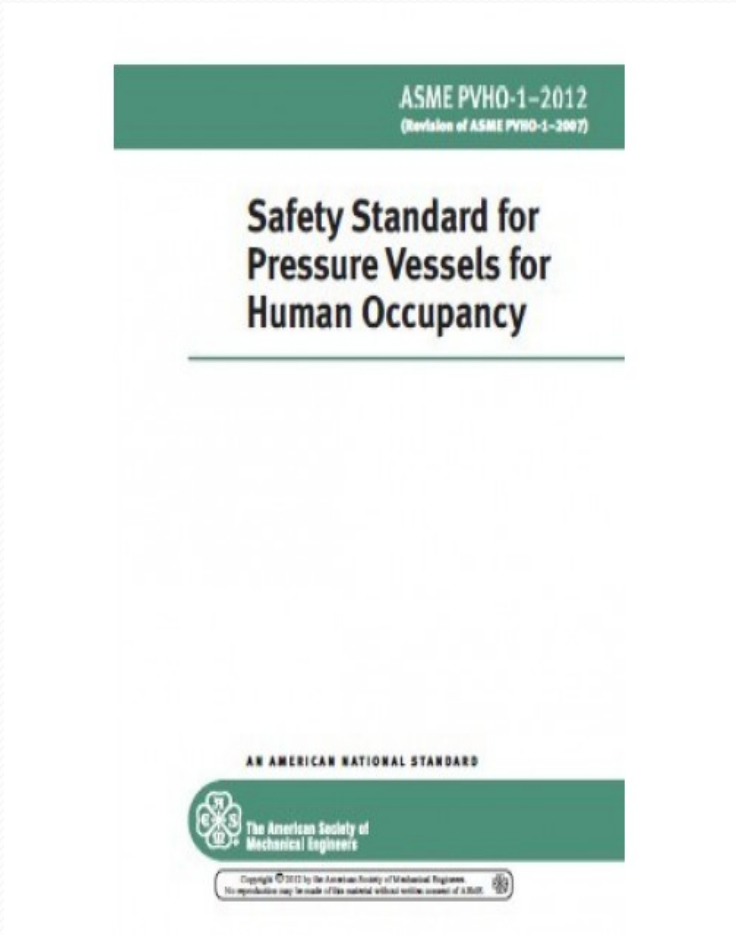








Publications



- Section 1: General
- Section 2: Viewports
- Section 3: QA for Manufacturers
- Section 4: Piping Systems
- Section 5: Medical Hyperbaric
- Section 6: Diving Systems
- Section 7: Submersibles

Section 1

References Boiler Code for specific design and fabrication criteria to include:

1. Cylinder Geometry
2. Allowable Material
3. Stiffening Requirement
4. Hatch/Door Design
5. Pressure Testing
6. Use of Non-Metallic Material

Section 1 General

Fig. 1-9(b)-1 Form of Nameplate, U.S. Customary

PVHO-1

Certified by

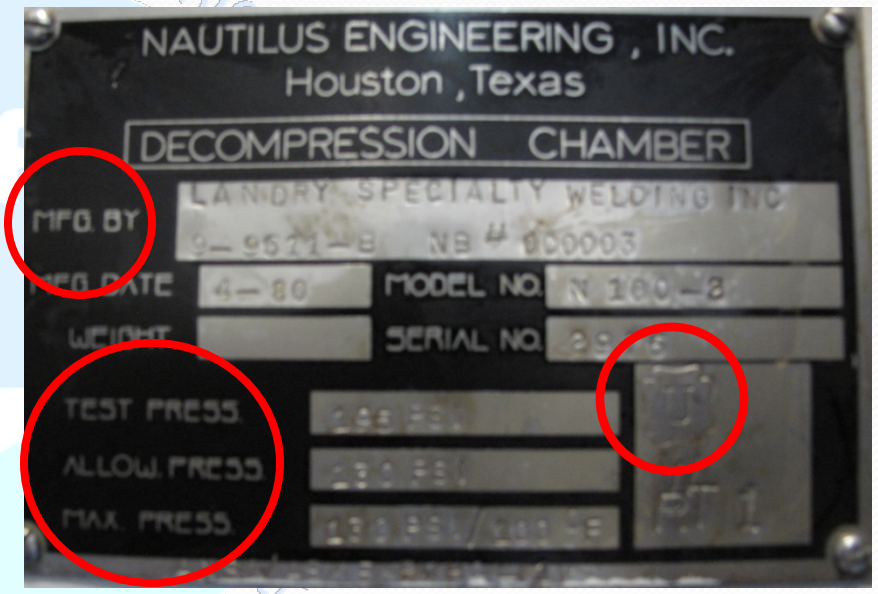
_____
(Name of manufacturer)

_____ psi internal _____ psi external
(Maximum allowable working pressures)

_____ °F maximum _____ °F minimum
(Design temperature range)

_____ _____
(Manufacturer's serial number) (Year built)

_____
(Design criteria)

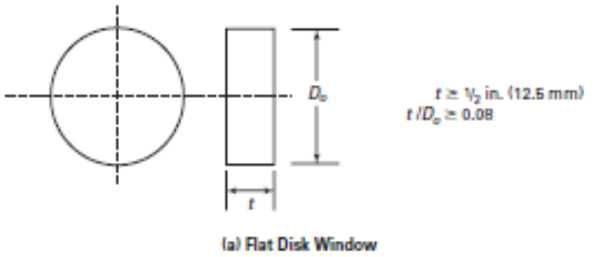


Section 2 Viewports

- Window Design
  1. *Shape*
  2. *Seating*
- Material of Construction
  1. *Acrylic Sheet Casting*
- Fabrication
  1. *Machining*
  2. *Annealing*
- Inspection
- Testing
- Installation

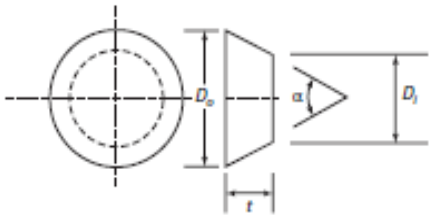
Standard Acrylic Geometry

Fig. 2-2.2.1-1 Standard Window Geometries



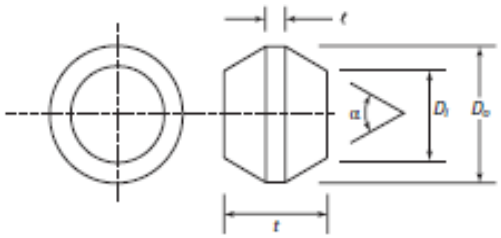
$t \geq 1/2$ in. (12.5 mm)
$t/D_o \geq 0.08$

(a) Flat Disk Window



$t \geq 1/2$ in. (12.5 mm)
$t/D_i \geq 0.125$
$\alpha \geq 60$ deg

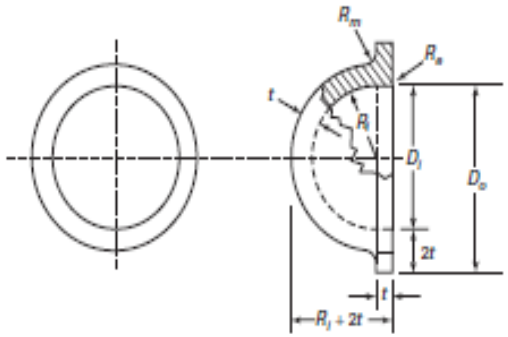
(b) Conical Frustum Window



$t \geq 1/2$ in. (12.5 mm)
$t/D_i \geq 0.250$
$\alpha \geq 60$ deg
$\ell \leq 0.25t$

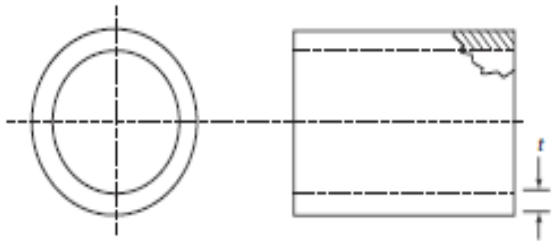
(c) Double Beveled Disk Window

Fig. 2-2.2.1-3 Standard Window Geometries



$t \geq 1/2$ in. (12.5 mm)
$0.2 \geq t/R_i \geq 0.03$
$D_o = (D_i + 4t)$
$R_m \geq 1/8$ in. (3.0 mm)
0.5 mm $\leq R_s \leq 0.125t$

(a) Hemispherical Window With Equatorial Flange



$t \geq 1/2$ in. (12.5 mm)

(b) Cylindrical Window

Section 4 Piping Systems

- Discusses detailed internal and external piping system design to include:

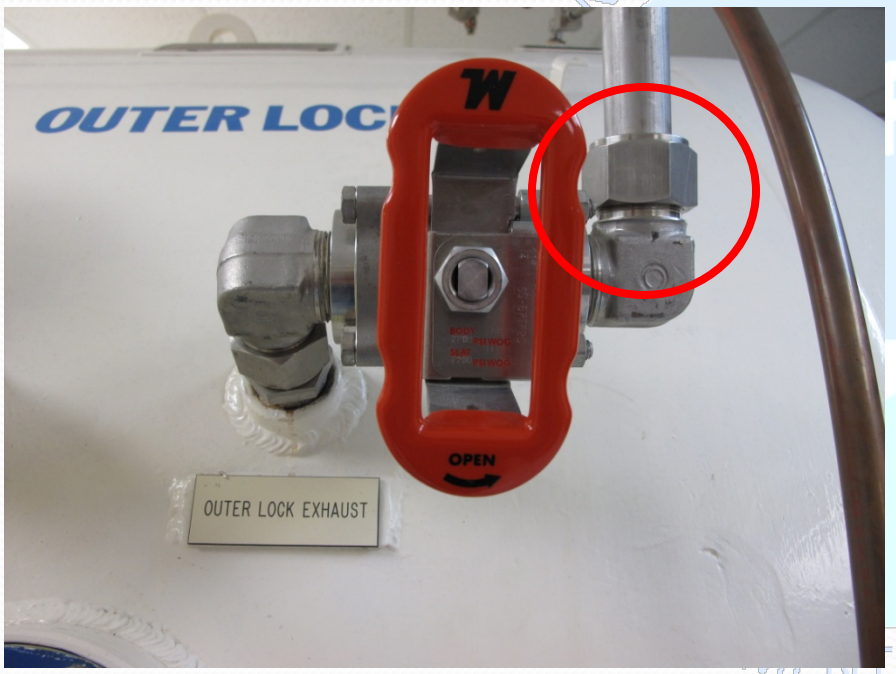
1. Materials
2. Service requirement
3. Valves
4. Breathing Gas System
5. Depth Gauges
6. Marking

Table 21-1. *Recompression Chamber Line Guide.*

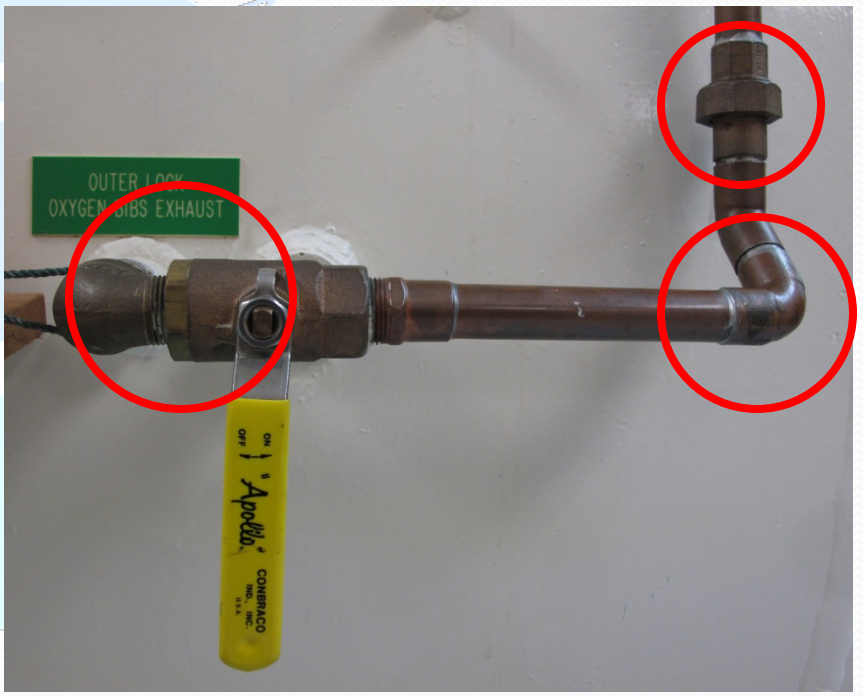
Function	Designation	Color Code
Helium	HE	Buff
Oxygen	OX	Green
Helium-Oxygen Mix	HE-OX	Buff & Green
Nitrogen	N	Light Gray
Nitrogen Oxygen Mix	N-OX	Light Gray & Green
Exhaust	E	Silver
Air (Low Pressure)	ALP	Black
Air (High Pressure)	AHP	Black
Chilled Water	CW	Blue & White
Hot Water	HW	Red & White
Potable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

Section 4

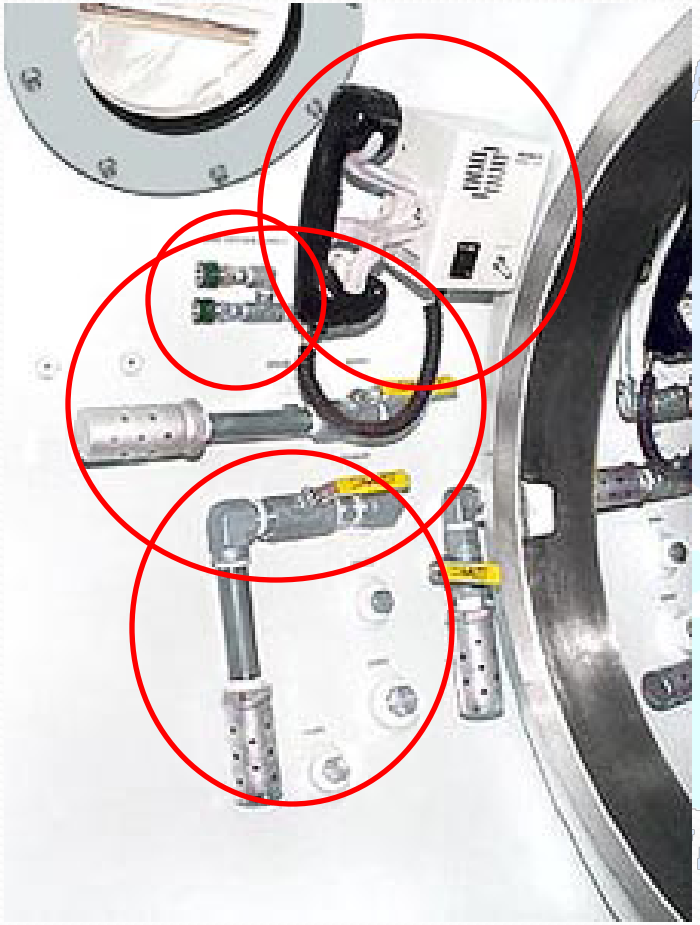
Exterior Tube



Exterior Brazed



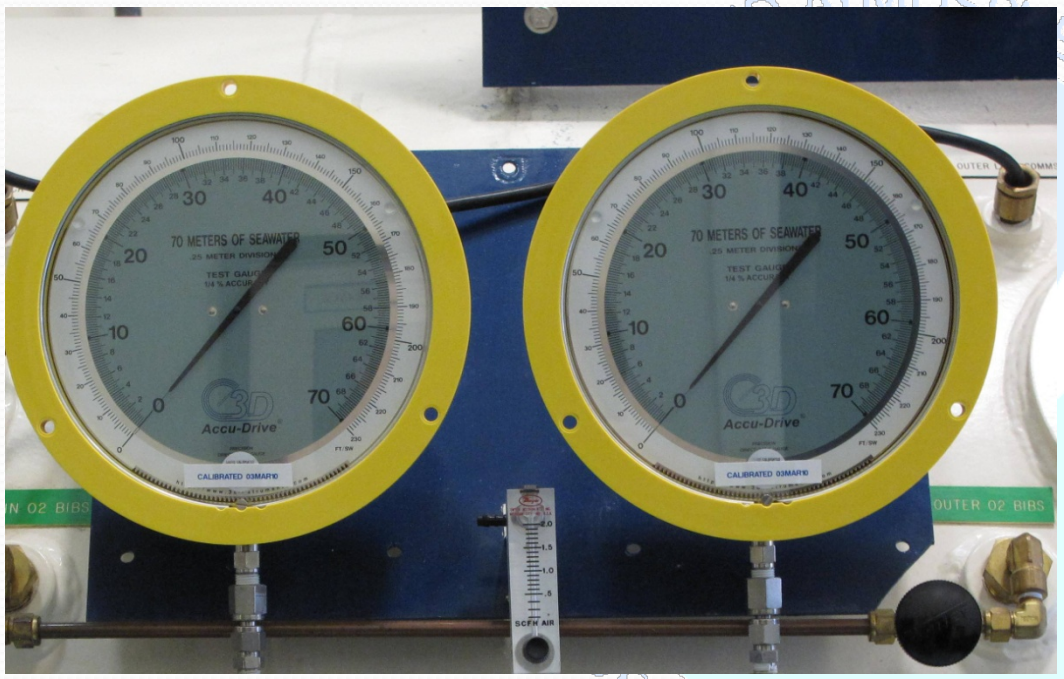
Interior Layout



- Inlet
- Exhaust
- BIBS
- Electrical

Valve Types

Gauges


70 METERS OF SEAWATER
Accu-Drive
CALIBRATED 03MAR10
SCFM AIR


SS TUBE
AND SOCKET
psi
McDaniel
Controls Inc.

Fire Suppression

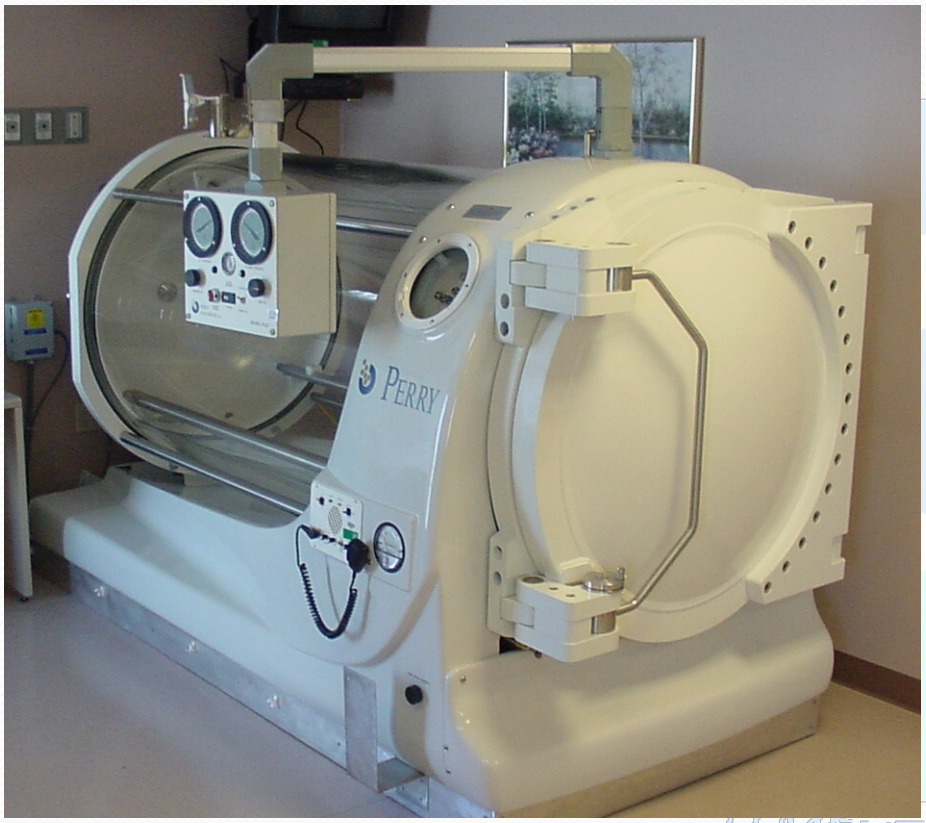
Treatment Lock required to have means of extinguishing fire. This can include:

1. Automated fire suppression system
2. Fire hose/ hand line
3. Fire Extinguisher
4. Bucket of water with fire blanket

Most clinical chamber systems will include both automated systems and hand lines.

Most deck decompression chamber systems will include only fire extinguishers and fire blankets

Section 5 Medical HBO



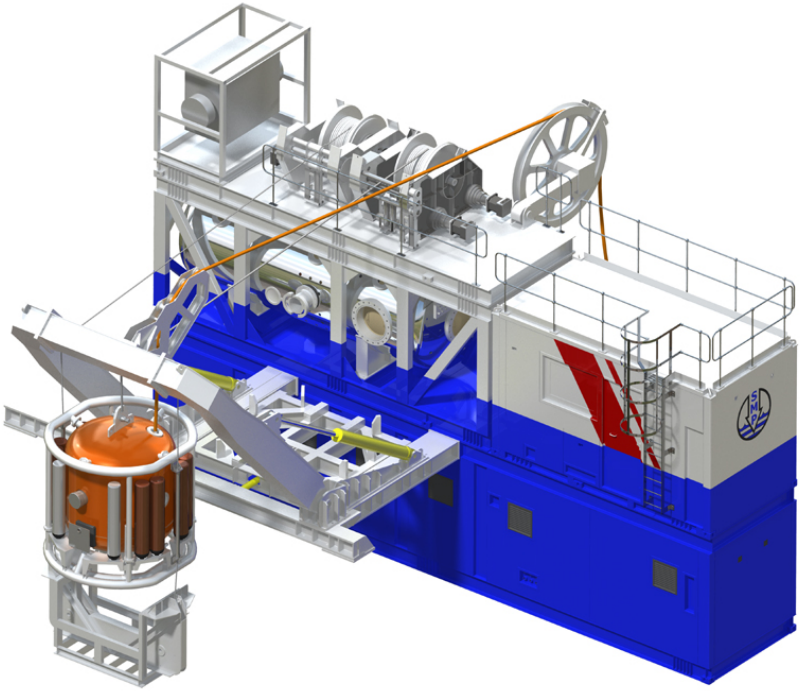
- Necessitates compliance with existing PVHO-1 *as well as* conformity to NFPA 99 guidelines
- Waves requirement for transfer lock in chambers rated to 3 ATA or less

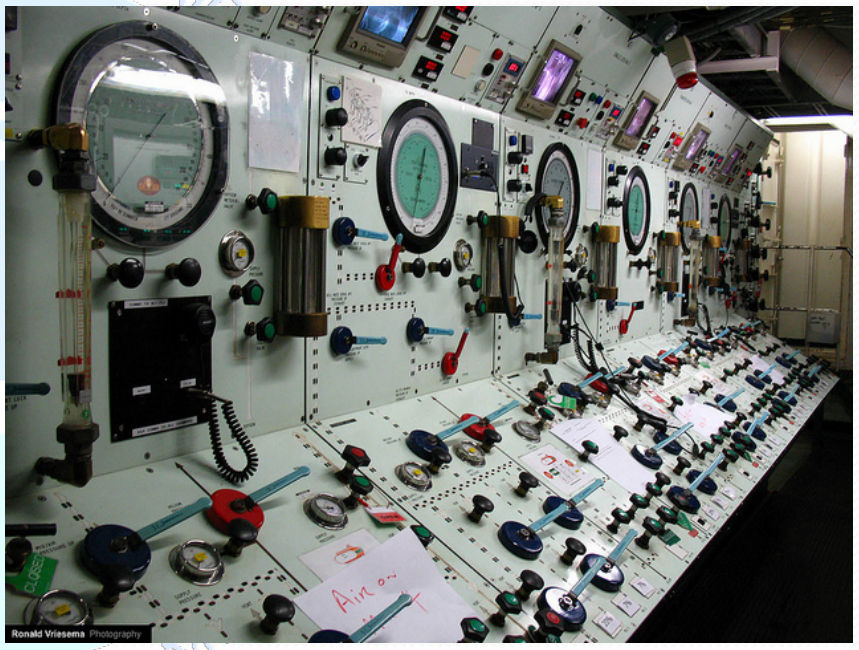
Section 6 Diving Systems

Consideration given to the type of service and operational environment each is exposed to in support of commercial diving operations

- Fabrication considerations for differential temperatures and corrosive marine environments
- Dynamic loading from transport, lifting, vibration, and wave action
- Distinct ergonomic space considerations for saturation systems
- Requirement for sanitation facilities (showers, toilets) in saturation
- Provision for design and integration of mating clamp and closures
- Design parameters for bell and PTC with respect to impact, mating, and ballast

Section 6 Diving Systems





Section 6 Diving Systems

Treatment Air Supply

Table 21-2. *Recompression Chamber Air Supply Requirements.*

Recompression Chamber Configuration	Primary Air Requirement	Secondary Air Requirement
CATEGORY A: No BIBS overboard dump No CO_2 scrubber No air BIBS No O_2 and CO_2 monitor	Sufficient air to press the IL once and the OL twice to 165 fsw and vent during one TT6A for one tender and two patients with maximum extensions.	Sufficient air to press the IL and OL once to 165 fsw and vent for one hour at 70.4 scfm.
CATEGORY B: BIBS overboard dump No CO_2 scrubber No air BIBS O_2 and CO_2 monitors	Sufficient air to press the IL once and the OL twice to 165 fsw and vent for CO_2 during one TT6A for one tender and two patients with maximum extensions.	Sufficient air to press the IL and OL once to 165 fsw and vent for one hour at 70.4 scfm.
CATEGORY C: BIBS overboard dump CO_2 scrubber No air BIBS O_2 and CO_2 monitors	Sufficient air to press the IL once and the OL twice to 165 fsw.	Sufficient air to press the IL and OL once to 165 fsw and vent for one hour at 70.4 scfm.
CATEGORY D: BIBS overboard dump CO_2 scrubber Air BIBS O_2 and CO_2 monitor	Sufficient air to press the IL once and the OL twice to 165 fsw. (For TRCS, sufficient air to power CO_2 scrubbers must be included)	Sufficient air to press the IL and OL once to 165 fsw and enough air for one tender and two patients (when not on O_2) to breathe air BIBS during one TT6A with maximum extensions.
CATEGORY E: BIBS overboard dump CO_2 scrubber O_2 and CO_2 monitor Spare CO_2 scrubber Secondary power supply NITROX BIBS No Air BIBS	Sufficient air to press the IL once and the OL twice to 165 fsw.	Sufficient air to press the IL and OL once to 165 fsw and enough air/NITROX for one tender and two patients (when not on O_2) to breathe air/NITROX BIBS during one TT6A with maximum extensions.

Notes:
1) Additional air source per PSOB will be required for TT4, 7 or 8.
2) For chambers used to conduct Sur "D" sufficient air is required to conduct a TT6A in addition to any planned Sur "D."
3) The requirement for BIBS overboard dump can also be satisfied with closed circuit BIBS with CO_2 scrubbers.

How do we know?

21-4 GAS SUPPLY

A recompression chamber system must have a primary and a secondary air supply system that satisfies Table 21-2. The purpose of this requirement is to ensure the recompression chamber system, at a minimum, is capable of conducting a Treatment Table 6A (TT6A).

21-4.1 Capacity. Either system may consist of air banks and/or a suitable compressor. The primary air supply system must have sufficient air to pressurize the inner lock once to 165 fsw and the outer lock twice to 165 fsw and ventilate the chamber as specified in Table 21-2.

- Primary System Capacity:

$C_p = (5 \times V_{il}) + (10 \times V_{ol}) + RV$

Where:

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

The secondary air supply system must have sufficient air to pressurize the inner and outer locks once to 165 fsw plus ventilate the chamber as specified in Table 21-2.

- Secondary System Requirement:

$C_s = (5 \times V_{il}) + (5 \times V_{ol}) + RV$

Where:

C_s = minimum capacity of secondary system in SCF
V_{il} = volume of inner lock
V_{ol} = volume of outer lock
5 = atmospheres equivalent to 165 fsw
RV = required ventilation. For Category A, B, and C, use 4,224 for ventilation rate of 70.4 scfm for one hour. For Category D and E, calculate air or NITROX required for two patients and one tender to breathe BIBS (when not on O_2) during one TT6A with maximum extensions.

Pre-dive Checklists

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	

RECOMPRESSION CHAMBER PREDIVE CHECKLIST		
Equipment		**Initials**
Electrical System		
Lights		
Carbon dioxide analyzer calibrated		
Oxygen analyzer calibrated		
Temperature indicator calibrated		
Carbon dioxide scrubber operational		
Chamber conditioning unit operational		
Direct Current (DC) power supply		
Ground Fault Interrupter (GFI)		
Communication System		
Primary system tested		
Secondary system tested		
Fire Prevention System		
Tank pressurized for chambers with installed fire suppression systems		
Combustible material in metal enclosure		
Fire-retardant clothing worn by all chamber occupants		
Fire-resistant mattresses and blankets in chamber		
Means of extinguishing a fire		
Miscellaneous		
Inside Chamber:	CO_2-absorbent canister with fresh absorbent installed	
	Urinal	
	Primary medical kit	
	Ear protection sound attenuators/ear protectors (1 set per person) Must have a 1/16" hole drilled to allow for equalization.	
Outside Chamber:	Heater/chiller unit	
	Stopwatches for recompression treatment time, decompression time, personnel leaving chamber time, and cumulative time	
	Fresh CO_2 scrubber canister	
	U.S. Navy Diving Manual, Volume 5	
	Ventilation bill	
	Chamber log	
	Operating Procedures (OPs) and Emergency Procedures (EPs)	
	Secondary medical kit	
	Bedpan (to be locked in as required)	

Post-dive Checklist

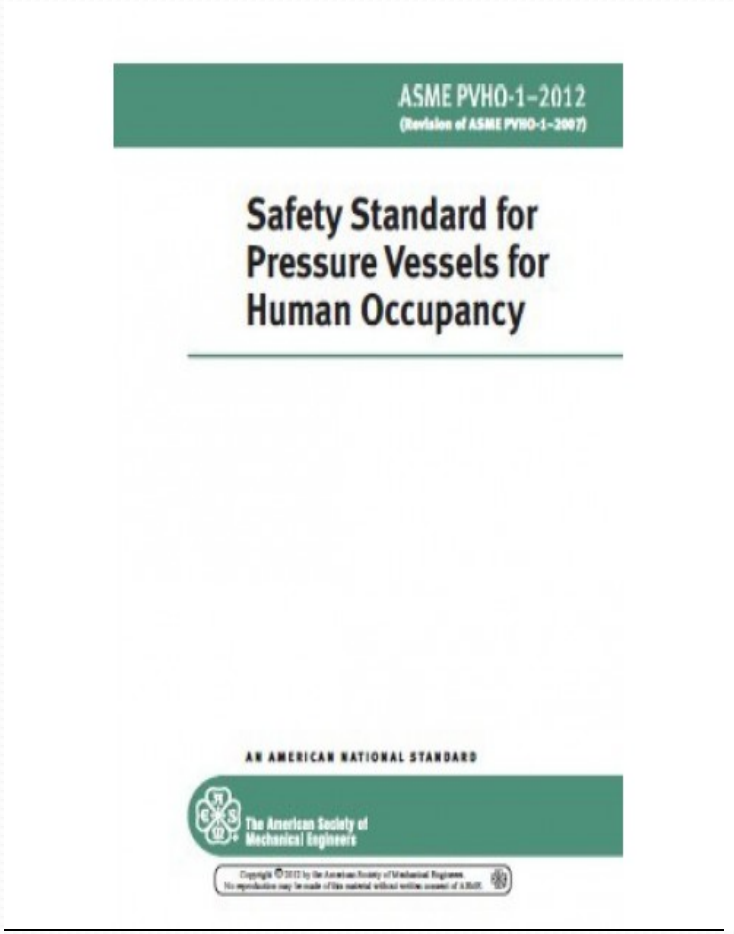
RECOMPRESSION CHAMBER POSTDIVE CHECKLIST	
Equipment	**Initials**
Air Supply	
All valves closed	
Air banks recharged, gauged, and pressure recorded	
Compressors fueled and maintained per technical manual/PMS requirements	
View Ports and Doors	
View-ports checked for damage; replaced as necessary	
Door seals checked, replaced as necessary	
Door seals lightly lubricated with approved lubricant	
Door dogs and dogging mechanism checked for proper operation and shaft seals for tightness	
Chamber	
Inside wiped clean with Nonionic Detergent (NID) and warm fresh water	
All unnecessary support items removed from chamber	
Blankets cleaned and replaced	
All flammable material in chamber encased in fire-resistant containers	
Primary medical kit restocked as 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	
U.S. Navy Diving Manual, 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	

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

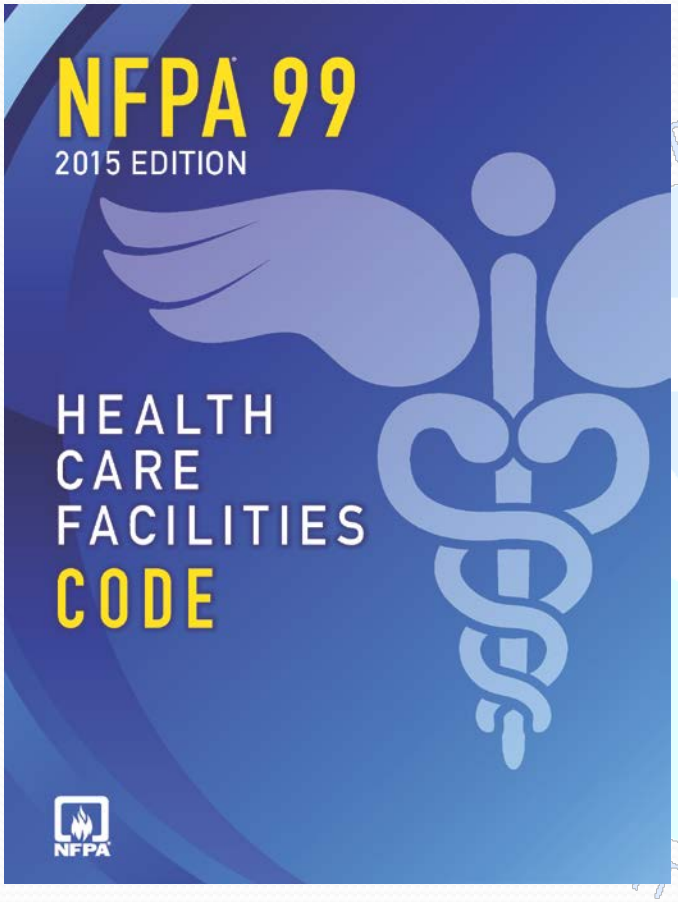
Section 7 Submersibles

- Design considerations must include operational maximums (depth, current, speed,)
- Considerations are made for internal power distribution (lighting, propulsion, life support, environmental control)
- Navigation, propulsion
- Communications
- Depth monitoring
- Buoyancy/CG consideration

Chamber Staffing

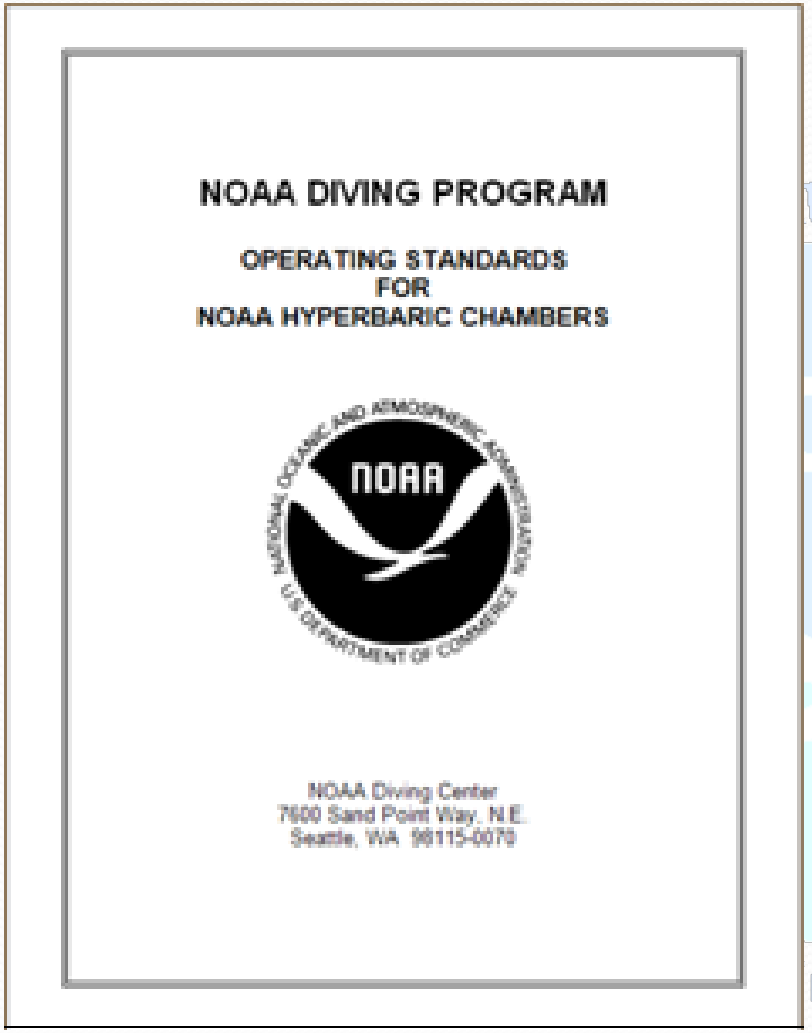


- *NO specific recommendations for staffing levels*
- Number of occupants rating
- Minimum flow ratings based on operational needs for atmospheric and treatment gases



- ONLY *specific* requirement: Hyperbaric Safety Director
- Safety Director, Facility management, and Medical Director responsible for developing, adopting, and enforcing operational procedures
- Medical and Safety Director develop minimum staff qualifications based on:

1. *Number and type of chambers*
2. *Maximum treatment capacity*
3. *Type of HBO therapy provided*



- **Multi-lock**

1. Supervisor/Operator
2. Inside Tender
3. Systems operator
4. Diving Medical Officer

- **Mono-lock/Multi-place**

1. Supervisor/Operator
2. Inside Tender
3. Systems operator
4. Diving Medical Officer

- **Mono-lock/Monoplace**

1. Supervisor/Operator
2. Timekeeper/system operator

Training and Certification

Questions?