

Diving Principles and Policy

1	History of Diving
2	Underwater Physics
3	Underwater Physiology
4	Dive Systems
5	Dive Program Administration
Appendix 1A	Safe Diving Distances from Transmitting Sonar
Appendix 1B	References
Appendix 1C	Telephone Numbers
Appendix 1D	List of Acronyms



Volume 1 - Table of Contents

Chap/Para	Page
1 HISTORY OF DIVING	
1-1 INTRODUCTION	1-1
1-1.1 Purpose	1-1
1-1.2 Scope	1-1
1-1.3 Role of the U.S. Navy	1-1
1-2 SURFACE-SUPPLIED AIR DIVING	1-1
1-2.1 Breathing Tubes	1-2
1-2.2 Breathing Bags	1-3
1-2.3 Diving Bells	1-3
1-2.4 Diving Dress Designs	1-3
1-2.4.1 Lethbridge's Diving Dress	1-3
1-2.4.2 Deane's Patented Diving Dress	1-4
1-2.4.3 Siebe's Improved Diving Dress	1-4
1-2.4.4 Salvage of the HMS Royal George	1-5
1-2.5 Caissons	1-5
1-2.6 Physiological Discoveries	1-6
1-2.6.1 Caisson Disease (Decompression Sickness)	1-6
1-2.6.2 Inadequate Ventilation	1-7
1-2.6.3 Nitrogen Narcosis	1-7
1-2.7 Armored Diving Suits	1-7
1-2.8 MK V Deep-Sea Diving Dress	1-8
1-3 SCUBA DIVING	1-8
1-3.1 Open-Circuit Scuba	1-9
1-3.1.1 Rouquayrol's Demand Regulator	1-9
1-3.1.2 LePrieur's Open-Circuit Scuba Design	1-9
1-3.1.3 Cousteau and Gagnan's Aqua-Lung	1-10
1-3.1.4 Impact of Scuba on Diving	1-10
1-3.2 Closed-Circuit Scuba	1-10
1-3.2.1 Fleuss' Closed-Circuit Scuba	1-10
1-3.2.2 Modern Closed-Circuit Systems	1-11
1-3.3 Hazards of Using Oxygen in Scuba	1-11
1-3.4 Semiclosed-Circuit Scuba	1-12
1-3.4.1 Lambertsen's Mixed-Gas Rebreather	1-12
1-3.4.2 MK 6 UBA	1-12
1-3.5 Scuba Use During World War II	1-13
1-3.5.1 Diver-Guided Torpedoes	1-13
1-3.5.2 U.S. Combat Swimming	1-14

Chap/Para		Page
	1-3.5.3 Underwater Demolition	1-15
1-4	MIXED-GAS DIVING	1-16
1-4.1	Nonsaturation Diving	1-16
1-4.1.1	Helium-Oxygen (HeO ₂) Diving	1-16
1-4.1.2	Hydrogen-Oxygen Diving	1-18
1-4.1.3	Modern Surface-Supplied Mixed-Gas Diving	1-19
1-4.1.4	MK 1 MOD 0 Diving Outfit.	1-20
1-4.2	Diving Bells	1-20
1-4.3	Saturation Diving	1-21
1-4.3.1	Advantages of Saturation Diving.	1-21
1-4.3.2	Bond's Saturation Theory	1-22
1-4.3.3	Genesis Project.	1-22
1-4.3.4	Developmental Testing	1-22
1-4.3.5	Sealab Program	1-22
1-4.4	Deep Diving Systems (DDS)	1-24
1-4.4.1	ADS-IV	1-25
1-4.4.2	MK 1 MOD 0	1-25
1-4.4.3	MK 2 MOD 0	1-25
1-4.4.4	MK 2 MOD 1	1-26
1-5	SUBMARINE SALVAGE AND RESCUE	1-26
1-5.1	USS F-4	1-26
1-5.2	USS S-51	1-27
1-5.3	USS S-4	1-27
1-5.4	USS Squalus	1-28
1-5.5	USS Thresher	1-28
1-5.6	Deep Submergence Systems Project	1-29
1-6	SALVAGE DIVING	1-29
1-6.1	World War II Era.	1-29
1-6.1.1	Pearl Harbor	1-29
1-6.1.2	USS Lafayette	1-29
1-6.1.3	Other Diving Missions.	1-30
1-6.2	Vietnam Era	1-30
1-7	OPEN-SEA DEEP DIVING RECORDS	1-30
1-8	SUMMARY	1-31
2	UNDERWATER PHYSICS	
2-1	INTRODUCTION	2-1
2-1.1	Purpose	2-1
2-1.2	Scope.	2-1

Chap/Para	Page
2-2 PHYSICS	2-1
2-3 MATTER	2-1
2-3.1 Elements	2-1
2-3.2 Atoms	2-1
2-3.3 Molecules	2-1
2-3.4 The Three States of Matter	2-2
2-4 MEASUREMENT	2-2
2-4.1 Measurement Systems	2-2
2-4.2 Temperature Measurements	2-3
2-4.2.1 Kelvin Scale	2-3
2-4.2.2 Rankine Scale	2-3
2-4.3 Gas Measurements	2-3
2-5 ENERGY	2-4
2-5.1 Conservation of Energy	2-5
2-5.2 Classifications of Energy	2-5
2-6 LIGHT ENERGY IN DIVING	2-5
2-6.1 Refraction	2-5
2-6.2 Turbidity of Water	2-6
2-6.3 Diffusion	2-6
2-6.4 Color Visibility	2-6
2-7 MECHANICAL ENERGY IN DIVING	2-6
2-7.1 Water Temperature and Sound	2-7
2-7.2 Water Depth and Sound	2-7
2-7.2.1 Diver Work and Noise	2-7
2-7.2.2 Pressure Waves	2-7
2-7.3 Underwater Explosions	2-8
2-7.3.1 Type of Explosive and Size of the Charge	2-8
2-7.3.2 Characteristics of the Seabed	2-8
2-7.3.3 Location of the Explosive Charge	2-8
2-7.3.4 Water Depth	2-8
2-7.3.5 Distance from the Explosion	2-8
2-7.3.6 Degree of Submersion of the Diver	2-9
2-7.3.7 Estimating Explosion Pressure on a Diver	2-9
2-7.3.8 Minimizing the Effects of an Explosion	2-10
2-8 HEAT ENERGY IN DIVING	2-10
2-8.1 Conduction, Convection, and Radiation	2-10
2-8.2 Heat Transfer Rate	2-11
2-8.3 Diver Body Temperature	2-11

Chap/Para		Page
2-9	PRESSURE IN DIVING	2-12
2-9.1	Atmospheric Pressure	2-12
2-9.2	Terms Used to Describe Gas Pressure	2-12
2-9.3	Hydrostatic Pressure	2-13
2-9.4	Buoyancy	2-13
2-9.4.1	Archimedes' Principle	2-13
2-9.4.2	Diver Buoyancy	2-14
2-10	GASES IN DIVING	2-14
2-10.1	Atmospheric Air	2-14
2-10.2	Oxygen	2-14
2-10.3	Nitrogen	2-15
2-10.4	Helium	2-15
2-10.5	Hydrogen	2-16
2-10.6	Neon	2-16
2-10.7	Carbon Dioxide	2-16
2-10.8	Carbon Monoxide	2-16
2-10.9	Kinetic Theory of Gases	2-16
2-11	GAS LAWS	2-17
2-11.1	Boyle's Law	2-17
2-11.2	Charles'/Gay-Lussac's Law	2-19
2-11.3	The General Gas Law	2-21
2-12	GAS MIXTURES	2-24
2-12.1	Dalton's Law	2-25
2-12.1.1	Expressing Small Quantities of Pressure	2-27
2-12.1.2	Calculating Surface Equivalent Value	2-27
2-12.2	Gas Diffusion	2-27
2-12.3	Humidity	2-28
2-12.4	Gases in Liquids	2-28
2-12.5	Solubility	2-28
2-12.6	Henry's Law	2-28
2-12.6.1	Gas Tension	2-28
2-12.6.2	Gas Absorption	2-29
2-12.6.3	Gas Solubility	2-29
3	UNDERWATER PHYSIOLOGY	
3-1	INTRODUCTION	3-1
3-1.1	Purpose	3-1
3-1.2	Scope	3-1

Chap/Para	Page
3-1.3 General	3-1
3-2 THE NERVOUS SYSTEM	3-1
3-3 THE CIRCULATORY SYSTEM	3-2
3-3.1 Anatomy	3-2
3-3.1.1 The Heart.	3-2
3-3.1.2 The Pulmonary and Systemic Circuits.	3-2
3-3.2 Circulatory Function	3-2
3-3.3 Blood Components	3-3
3-4 THE RESPIRATORY SYSTEM	3-5
3-4.1 Gas Exchange	3-5
3-4.2 Respiration Phases	3-5
3-4.3 Upper and Lower Respiratory Tract	3-6
3-4.4 The Respiratory Apparatus	3-6
3-4.4.1 The Chest Cavity.	3-6
3-4.4.2 The Lungs.	3-6
3-4.5 Respiratory Tract Ventilation Definitions	3-7
3-4.5.1 Respiratory Cycle.	3-7
3-4.5.2 Respiratory Rate.	3-8
3-4.5.3 Total Lung Capacity.	3-8
3-4.5.4 Vital Capacity.	3-8
3-4.5.5 Tidal Volume.	3-8
3-4.5.6 Respiratory Minute Volume.	3-8
3-4.5.7 Maximal Breathing Capacity and Maximum Ventilatory Volume.	3-9
3-4.5.8 Maximum Inspiratory Flow Rate and Maximum Expiratory Flow Rate.	3-9
3-4.5.9 Respiratory Quotient.	3-9
3-4.5.10 Respiratory Dead Space.	3-9
3-4.6 Alveolar/Capillary Gas Exchange.	3-9
3-4.7 Breathing Control	3-10
3-4.8 Oxygen Consumption.	3-10
3-5 RESPIRATORY PROBLEMS IN DIVING	3-11
3-5.1 Oxygen Deficiency (Hypoxia)	3-11
3-5.1.1 Causes of Hypoxia.	3-13
3-5.1.2 Symptoms of Hypoxia.	3-13
3-5.1.3 Treating Hypoxia.	3-14
3-5.1.4 Preventing Hypoxia.	3-14
3-5.2 Carbon Dioxide Toxicity (Hypercapnia)	3-15
3-5.2.1 Causes of Hypercapnia.	3-15
3-5.2.2 Symptoms of Hypercapnia.	3-15
3-5.2.3 Treating Hypercapnia.	3-16
3-5.3 Asphyxia.	3-16
3-5.4 Breathing Resistance and Dyspnea.	3-17

Chap/Para		Page
	3-5.4.1 Causes of Breathing Resistance.	3-17
	3-5.4.2 Preventing Dyspnea.	3-18
3-5.5	Carbon Monoxide Poisoning	3-18
	3-5.5.1 Symptoms of Carbon Monoxide Poisoning.	3-18
	3-5.5.2 Treating Carbon Monoxide Poisoning.	3-19
	3-5.5.3 Preventing Carbon Monoxide Poisoning.	3-19
3-6	BREATHHOLDING AND UNCONSCIOUSNESS.	3-19
3-6.1	Breathhold Diving Restrictions.	3-19
3-6.2	Hazards of Breathhold Diving	3-19
3-7	HYPERVENTILATION.	3-20
3-7.1	Unintentional Hyperventilation	3-20
3-7.2	Voluntary Hyperventilation	3-20
3-8	EFFECTS OF BAROTRAUMA AND PRESSURE ON THE HUMAN BODY	3-20
3-8.1	Conditions Leading to Barotrauma.	3-21
3-8.2	General Symptoms of Barotrauma.	3-21
3-8.3	Middle Ear Squeeze.	3-21
	3-8.3.1 Preventing Middle Ear Squeeze.	3-23
	3-8.3.2 Treating Middle Ear Squeeze.	3-23
3-8.4	Sinus Squeeze.	3-23
	3-8.4.1 Causes of Sinus Squeeze.	3-23
	3-8.4.2 Preventing Sinus Squeeze.	3-24
3-8.5	Tooth Squeeze (Barodontalgia)	3-24
3-8.6	External Ear Squeeze	3-24
3-8.7	Thoracic (Lung) Squeeze.	3-25
3-8.8	Face or Body Squeeze.	3-25
3-8.9	Middle Ear Overpressure (Reverse Middle Ear Squeeze)	3-25
3-8.10	Sinus Overpressure (Reverse Sinus Squeeze)	3-26
3-8.11	Overexpansion of the Stomach and Intestine	3-26
3-8.12	Inner Ear Dysfunction.	3-26
	3-8.12.1 Vertigo.	3-26
	3-8.12.2 Inner Ear Barotrauma.	3-27
3-9	PULMONARY OVERINFLATION SYNDROMES	3-28
3-9.1	Arterial Gas Embolism	3-29
3-9.2	Mediastinal and Subcutaneous Emphysema.	3-30
3-9.3	Pneumothorax	3-30
3-10	INDIRECT EFFECTS OF PRESSURE	3-32
3-10.1	Nitrogen Narcosis.	3-32
	3-10.1.1 Symptoms of Narcosis.	3-33

Chap/Para	Page
3-10.1.2 Susceptibility to Narcosis.	3-33
3-10.2 Oxygen Toxicity	3-34
3-10.2.1 Pulmonary Oxygen Toxicity.	3-35
3-10.2.2 Central Nervous System (CNS) Oxygen Toxicity.	3-35
3-10.2.3 CNS Convulsions.	3-36
3-10.3 Absorption of Inert Gases.	3-38
3-10.4 Saturation of Tissues	3-38
3-10.4.1 Nitrogen Saturation Process.	3-38
3-10.4.2 Other Inert Gases.	3-40
3-10.5 Desaturation of Tissues	3-41
3-10.5.1 Saturation/Desaturation Differences.	3-41
3-10.5.2 Bubble Formation.	3-42
3-10.6 Decompression Sickness.	3-42
3-10.6.1 Direct Bubble Effects.	3-42
3-10.6.2 Indirect Bubble Effects.	3-43
3-10.6.3 Symptoms of Decompression Sickness.	3-43
3-10.6.4 Treating Decompression Sickness.	3-44
3-10.6.5 Preventing Decompression Sickness.	3-44
3-10.7 High Pressure Nervous Syndrome (HPNS)	3-45
3-10.8 Compression Pains	3-45
3-11 PHYSIOLOGICAL HAZARDS FROM MUNITIONS	3-45
3-12 THERMAL PROBLEMS AND OTHER PHYSIOLOGICAL PROBLEMS IN DIVING	3-46
3-12.1 Regulating Body Temperature	3-47
3-12.2 Excessive Heat Loss (Hypothermia)	3-47
3-12.2.1 Internal Temperature Regulation.	3-48
3-12.2.2 Effects of Exercise on Hypothermia.	3-48
3-12.2.3 Symptoms of Hypothermia.	3-48
3-12.3 Excessive Heat (Hyperthermia)	3-49
3-12.3.1 Heat Stress Factors.	3-49
3-12.3.2 Acclimatization.	3-50
3-12.3.3 Symptoms of Hyperthermia.	3-50
3-12.3.4 Impact of Dive Time on Hyperthermia.	3-50
3-12.3.5 Preventing Hyperthermia.	3-51
3-12.4 Dehydration	3-51
3-12.4.1 Causes of Dehydration.	3-52
3-12.4.2 Preventing Dehydration.	3-52
3-12.5 Hypoglycemia.	3-52
3-12.5.1 Symptoms of Hypoglycemia.	3-52
3-12.5.2 Causes of Hypoglycemia.	3-52
3-12.5.3 Preventing Hypoglycemia.	3-52

Chap/Para		Page
4	DIVE SYSTEMS	
4-1	INTRODUCTION	4-1
4-1.1	Purpose	4-1
4-1.2	Scope	4-1
4-2	GENERAL INFORMATION	4-1
4-2.1	Document Precedence	4-1
4-2.2	Equipment Authorized For Navy Use (ANU)	4-1
4-2.3	System Certification Authority (SCA)	4-2
4-2.4	Planned Maintenance System	4-2
4-2.5	Alteration of Diving Equipment	4-2
4-2.5.1	Technical Program Managers for Shore-Based Systems	4-2
4-2.5.2	Technical Program Managers for Other Diving Apparatus	4-2
4-2.6	Operating and Emergency Procedures	4-2
4-2.6.1	Standardized OP/EPs	4-2
4-2.6.2	Non-standardized OP/EPs	4-3
4-2.6.3	OP/EP Approval Process	4-3
4-2.6.4	Format	4-3
4-2.6.5	Example	4-4
4-3	DIVER'S BREATHING GAS PURITY STANDARDS	4-4
4-3.1	Diver's Breathing Air	4-4
4-3.2	Diver's Breathing Oxygen	4-4
4-3.3	Diver's Breathing Helium	4-5
4-3.4	Diver's Breathing Nitrogen	4-5
4-4	DIVER'S AIR SAMPLING PROGRAM	4-5
4-4.1	Maintenance Requirements	4-6
4-4.2	General Air Sampling Procedures	4-8
4-4.3	CSS Air Sampling Services	4-9
4-4.4	Local Air Sampling Services	4-10
4-5	DIVING COMPRESSORS	4-10
4-5.1	Equipment Requirements	4-10
4-5.2	Air Filtration System	4-10
4-5.3	Lubrication	4-10
4-6	DIVING GAUGES	4-11
4-6.1	Selecting Diving System Guages	4-11
4-6.2	Calibrating and Maintaining Gauges	4-11
4-6.3	Helical Bourdon Tube Gauges	4-12
4-7	COMPRESSED GAS HANDLING AND STORAGE	4-13

Chap/Para	Page
5 DIVE PROGRAM ADMINISTRATION	
5-1 INTRODUCTION	5-1
5-1.1 Purpose	5-1
5-1.2 Scope	5-1
5-2 OBJECTIVES OF THE RECORD KEEPING AND REPORTING SYSTEM	5-1
5-3 RECORD KEEPING AND REPORTING DOCUMENTS	5-1
5-4 COMMAND SMOOTH DIVING LOG	5-2
5-5 RECOMPRESSION CHAMBER LOG	5-2
5-6 DIVER'S PERSONAL DIVE LOG	5-9
5-7 DIVING MISHAP/CASUALTY REPORTING	5-9
5-8 EQUIPMENT FAILURE OR DEFICIENCY REPORTING	5-10
5-9 U.S. NAVY DIVE REPORTING SYSTEM (DRS)	5-10
5-10 ACCIDENT/INCIDENT EQUIPMENT INVESTIGATION REQUIREMENTS	5-10
5-11 REPORTING CRITERIA	5-11
5-12 ACTIONS REQUIRED	5-11
5-12.1 Technical Manual Deficiency/Evaluation Report	5-13
5-12.2 Shipment of Equipment	5-13
1A SAFE DIVING DISTANCES FROM TRANSMITTING SONAR	
1A-1 INTRODUCTION	1A-1
1A-2 BACKGROUND	1A-1
1A-3 ACTION	1A-2
1A-4 SONAR DIVING DISTANCES WORKSHEETS WITH DIRECTIONS FOR USE	1A-2
1A-4.1 General Information/Introduction	1A-2
1A-4.1.1 Effects of Exposure	1A-2
1A-4.1.2 Suit and Hood Characteristics	1A-2
1A-4.1.3 In-Water Hearing vs. In-Gas Hearing	1A-2
1A-4.2 Directions for Completing the Sonar Diving Distances Worksheet	1A-3
1A-5 GUIDANCE FOR DIVER EXPOSURE TO LOW-FREQUENCY SONAR (160–320 Hz) ..	1A-16
1A-6 GUIDANCE FOR DIVER EXPOSURE TO ULTRASONIC SONAR (250 KHz AND GREATER)	1A-16

1B REFERENCES

1C TELEPHONE NUMBERS

1D LIST OF ACRONYMS

Air Diving Operations

6	Operational Planning
7	Scuba Air Diving Operations
8	Surface-Supplied Air Diving Operations
9	Air Decompression
10	Nitrogen-Oxygen Diving Operations
11	Ice and Cold Water Diving Operations



Volume 2 - Table of Contents

Chap/Para		Page
6	OPERATIONAL PLANNING	
6-1	INTRODUCTION	6-1
6-1.1	Purpose.	6-1
6-1.2	Scope.	6-1
6-2	GENERAL PLANNING CONSIDERATIONS	6-1
6-2.1	Identifying Available Resources	6-1
6-3	DEFINE MISSION OBJECTIVE	6-2
6-4	IDENTIFY OPERATIONAL TASKS	6-2
6-4.1	Underwater Ship Husbandry (UWSH).	6-2
6-4.1.1	Objective of UWSH Operations	6-2
6-4.1.2	Repair Requirements	6-2
6-4.1.3	Diver Training and Qualification Requirements	6-3
6-4.1.4	Training Program Requirements	6-3
6-4.2	Salvage/Object Recovery	6-3
6-4.3	Search Missions	6-3
6-4.4	Security Swims	6-4
6-4.5	Explosive Ordnance Disposal	6-4
6-4.6	Underwater Construction	6-5
6-4.6.1	Diver Training and Qualification Requirements	6-5
6-4.6.2	Equipment Requirements.	6-5
6-4.6.3	Underwater Construction Planning Resources.	6-5
6-4.7	Demolition Missions	6-6
6-4.8	Combat Swimmer Missions	6-6
6-4.9	Enclosed Space Diving.	6-6
6-5	COLLECT AND ANALYZE DATA	6-6
6-5.1	Information Gathering	6-7
6-5.2	Planning Data.	6-7
6-5.2.1	Object Recovery	6-7
6-5.2.2	Searching for Objects or Underwater Sites.	6-7
6-5.2.3	Identifying Operational Hazards	6-8
6-5.3	Data Required for All Diving Operations.	6-8
6-5.3.1	Surface Conditions	6-9
6-5.3.2	Natural Factors	6-9
6-5.3.3	Depth	6-13
6-5.3.4	Type of Bottom	6-13
6-5.3.5	Tides and Currents.	6-14

Chap/Para		Page
6-6	IDENTIFY ENVIRONMENTAL AND OPERATIONAL HAZARDS	6-15
6-6.1	Underwater Visibility	6-15
6-6.2	Temperature	6-15
6-6.3	Contaminated Water	6-15
6-6.4	Thermal Pollution	6-17
6-6.5	Chemical Contamination	6-17
6-6.6	Biological Contamination	6-17
6-6.7	Altitude Diving	6-17
6-6.8	Underwater Obstacles	6-17
6-6.9	Electrical Shock Hazards	6-18
6-6.9.1	Reducing Electrical Shock Hazards	6-18
6-6.9.2	Securing Electrical Equipment	6-19
6-6.10	Explosions	6-19
6-6.11	Sonar	6-19
6-6.12	Nuclear Radiation	6-20
6-6.13	Marine Life	6-20
6-6.14	Vessel and Small Boat Traffic	6-20
6-6.15	Territorial Waters	6-20
6-7	SELECT DIVING TECHNIQUE	6-20
6-7.1	Factors to Consider when Selecting the Diving Technique	6-22
6-7.2	Operational Characteristics of Scuba	6-24
6-7.2.1	Mobility	6-24
6-7.2.2	Buoyancy	6-24
6-7.2.3	Portability	6-24
6-7.2.4	Operational Limitations	6-24
6-7.2.5	Environmental Protection	6-24
6-7.3	Operational Characteristics of SSDS	6-25
6-7.3.1	Mobility	6-25
6-7.3.2	Buoyancy	6-25
6-7.3.3	Operational Limitations	6-25
6-7.3.4	Environmental Protection	6-25
6-8	SELECT EQUIPMENT AND SUPPLIES	6-25
6-8.1	Equipment Authorized for Navy Use	6-25
6-8.2	Air Supply	6-25
6-8.3	Diving Craft and Platforms	6-26
6-8.3.1	Deep-Sea Salvage/Rescue Diving Platforms	6-26
6-8.3.2	Small Craft	6-26
6-9	SELECT AND ASSEMBLE THE DIVING TEAM	6-27
6-9.1	Manning Levels	6-27
6-9.2	Commanding Officer	6-29

Chap/Para		Page
6-9.3	Diving Officer	6-29
6-9.3.1	Command Diving Officer.	6-29
6-9.3.2	Watchstation Diving Officer	6-29
6-9.4	Master Diver	6-29
6-9.4.1	Master Diver Responsibilities.	6-29
6-9.4.2	Master Diver Qualifications.	6-30
6-9.5	Diving Supervisor	6-30
6-9.5.1	Predive Responsibilities	6-30
6-9.5.2	Responsibilities While Operation is Underway	6-30
6-9.5.3	Postdive Responsibilities	6-30
6-9.5.4	Diving Supervisor Qualifications.	6-31
6-9.6	Diving Medical Officer	6-31
6-9.7	Diving Personnel	6-31
6-9.7.1	Diving Personnel Responsibilities.	6-31
6-9.7.2	Diving Personnel Qualifications	6-31
6-9.8	Standby Diver	6-32
6-9.8.1	Standby Diver Qualifications	6-32
6-9.8.2	Deploying the Standby Diver as a Working Diver.	6-32
6-9.9	Buddy Diver	6-33
6-9.10	Diver Tender	6-33
6-9.10.1	Diver Tender Responsibilities.	6-33
6-9.10.2	Diver Tender Qualifications	6-33
6-9.11	Recorder	6-33
6-9.12	Medical Personnel	6-33
6-9.13	Other Support Personnel	6-34
6-9.14	Cross-Training and Substitution	6-34
6-9.15	Physical Condition.	6-34
6-9.16	Underwater Salvage or Construction Demolition Personnel.	6-35
6-9.16.1	Blasting Plan.	6-35
6-9.16.2	Explosive Handlers.	6-35
6-10	OSHA REQUIREMENTS FOR U.S NAVY CIVILIAN DIVING.	6-35
6-10.1	Scuba Diving (Air) Restriction	6-35
6-10.2	Surface-Supplied Air Diving Restrictions	6-36
6-10.3	Mixed-Gas Diving Restrictions	6-36
6-10.4	Recompression Chamber Requirements	6-36
6-11	ORGANIZE AND SCHEDULE OPERATIONS	6-36
6-11.1	Task Planning and Scheduling.	6-36
6-11.2	Postdive Tasks.	6-37
6-12	BRIEF THE DIVING TEAM	6-38
6-12.1	Establish Mission Objective.	6-38

Chap/Para		Page
6-12.2	Identify Tasks and Procedures.	6-38
6-12.3	Review Diving Procedures.. . . .	6-38
6-12.4	Assignment of Personnel.. . . .	6-38
6-12.5	Assistance and Emergencies.	6-38
6-12.5.1	Notification of Ship's Personnel.. . . .	6-48
6-12.5.2	Fouling and Entrapment.	6-48
6-12.5.3	Equipment Failure.. . . .	6-50
6-12.5.4	Lost Diver.	6-50
6-12.5.5	Debriefing the Diving Team.. . . .	6-51
6-13	AIR DIVING EQUIPMENT REFERENCE DATA	6-51
7	SCUBA AIR DIVING OPERATIONS	
7-1	INTRODUCTION	7-1
7-1.1	Purpose	7-1
7-1.2	Scope	7-1
7-2	REQUIRED EQUIPMENT FOR SCUBA OPERATIONS	7-1
7-2.1	Equipment Authorized for Navy Use.	7-2
7-2.2	Open-Circuit Scuba	7-2
7-2.2.1	Demand Regulator Assembly.	7-2
7-2.2.2	Cylinders.	7-4
7-2.2.3	Cylinder Valves and Manifold Assemblies.	7-6
7-2.2.4	Backpack or Harness.	7-7
7-2.3	Minimum Equipment.	7-7
7-2.3.1	Face Mask	7-7
7-2.3.2	Life Preserver.	7-7
7-2.3.3	Buoyancy Compensator.	7-8
7-2.3.4	Weight Belt.	7-9
7-2.3.5	Knife.	7-9
7-2.3.6	Swim Fins.	7-10
7-2.3.7	Wrist Watch	7-10
7-2.3.8	Depth Gauge	7-10
7-3	OPTIONAL EQUIPMENT FOR SCUBA OPERATIONS	7-10
7-3.1	Protective Clothing	7-11
7-3.1.1	Wet Suits.. . . .	7-11
7-3.1.2	Dry Suits.	7-12
7-3.1.3	Gloves.. . . .	7-12
7-3.1.4	Writing Slate.	7-12
7-3.1.5	Signal Flare	7-12
7-3.1.6	Acoustic Beacons.	7-12
7-3.1.7	Lines and Floats.	7-12
7-3.1.8	Snorkel.	7-13
7-3.1.9	Compass	7-13
7-3.1.10	Submersible Cylinder Pressure Gauge	7-13

Chap/Para		Page
7-4	AIR SUPPLY	7-13
7-4.1	Duration of Air Supply	7-14
7-4.2	Compressed Air from Commercial Sources	7-16
7-4.3	Methods for Charging Scuba Cylinders	7-17
7-4.4	Operating Procedures for Charging Scuba Tanks	7-18
7-4.4.1	Topping off the Scuba Cylinder	7-19
7-4.5	Safety Precautions for Charging and Handling Cylinders	7-20
7-5	PREDIVE PROCEDURES	7-21
7-5.1	Equipment Preparation	7-21
7-5.1.1	Air Cylinders	7-21
7-5.1.2	Harness Straps and Backpack	7-22
7-5.1.3	Breathing Hoses	7-22
7-5.1.4	Regulator	7-22
7-5.1.5	Life Preserver/Buoyancy Compensator (BC)	7-22
7-5.1.6	Face Mask	7-23
7-5.1.7	Swim Fins	7-23
7-5.1.8	Dive Knife	7-23
7-5.1.9	Snorkel	7-23
7-5.1.10	Weight Belt	7-23
7-5.1.11	Submersible Wrist Watch	7-23
7-5.1.12	Depth Gauge and Compass	7-23
7-5.1.13	Miscellaneous Equipment	7-24
7-5.2	Diver Preparation and Brief	7-24
7-5.3	Donning Gear	7-24
7-5.4	Predive Inspection	7-25
7-6	WATER ENTRY AND DESCENT	7-26
7-6.1	Water Entry	7-26
7-6.1.1	Step-In Method	7-28
7-6.1.2	Rear Roll Method	7-28
7-6.1.3	Entering the Water from the Beach	7-28
7-6.2	Predescent Surface Check	7-28
7-6.3	Surface Swimming	7-29
7-6.4	Descent	7-29
7-7	UNDERWATER PROCEDURES	7-30
7-7.1	Breathing Technique	7-30
7-7.2	Mask Clearing	7-30
7-7.3	Hose and Mouthpiece Clearing	7-30
7-7.4	Swimming Technique	7-31
7-7.5	Diver Communications	7-31
7-7.5.1	Through-Water Communication Systems	7-32
7-7.5.2	Hand and Line-Pull Signals	7-32

Chap/Para		Page
7-7.6	Buddy Diver Responsibilities	7-32
7-7.7	Buddy Breathing Procedure	7-35
7-7.8	Tending	7-36
7-7.8.1	Tending with a Surface or Buddy Line	7-36
7-7.8.2	Tending with No Surface Line	7-37
7-7.9	Working with Tools	7-37
7-7.10	Adapting to Underwater Conditions	7-37
7-8	ASCENT PROCEDURES	7-38
7-8.1	Emergency Free-Ascent Procedures	7-38
7-8.2	Ascent From Under a Vessel	7-39
7-8.3	Decompression	7-39
7-8.4	Surfacing and Leaving the Water	7-40
7-9	POSTDIVE PROCEDURES	7-40
8	SURFACE-SUPPLIED AIR DIVING OPERATIONS	
8-1	INTRODUCTION	8-1
8-1.1	Purpose	8-1
8-1.2	Scope	8-1
8-2	MK 21 MOD 1	8-1
8-2.1	Operation and Maintenance	8-1
8-2.2	Air Supply	8-1
8-2.2.1	Emergency Gas Supply Requirements	8-2
8-2.2.2	Flow Requirements	8-2
8-2.2.3	Pressure Requirements	8-2
8-3	MK 20 MOD 0	8-5
8-3.1	Operation and Maintenance	8-5
8-3.2	Air Supply	8-6
8-3.2.1	EGS Requirements for MK 20 MOD 0 Enclosed-Space Diving	8-6
8-3.2.2	Flow Requirements	8-6
8-4	PORTABLE SURFACE-SUPPLIED DIVING SYSTEMS	8-6
8-4.1	MK 3 MOD 0 Lightweight Dive System (LWDS)	8-6
8-4.1.1	MK 3 MOD 0 Configuration 1.	8-7
8-4.1.2	MK 3 MOD 0 Configuration 2.	8-7
8-4.1.3	MK 3 MOD 0 Configuration 3.	8-7
8-4.2	MK 3 MOD 1 Lightweight Dive System.	8-7
8-4.3	ROPER Diving Cart	8-9
8-4.4	Flyaway Dive System (FADS) I	8-9

Chap/Para		Page
8-4.5	Flyaway Dive System (FADS) II	8-10
8-4.6	Flyaway Dive System (FADS) III.	8-12
8-5	ACCESSORY EQUIPMENT FOR SURFACE-SUPPLIED DIVING	8-12
8-6	SURFACE AIR SUPPLY SYSTEMS	8-13
8-6.1	Requirements for Air Supply	8-13
8-6.1.1	Air Purity Standards	8-13
8-6.1.2	Air Supply Flow Requirements	8-14
8-6.1.3	Supply Pressure Requirements.	8-14
8-6.1.4	Water Vapor Control.	8-15
8-6.1.5	Standby Diver Air Requirements	8-15
8-6.2	Primary and Secondary Air Supply	8-15
8-6.2.1	Requirements for Operating Procedures and Emergency Procedures.	8-15
8-6.2.2	Air Compressors.	8-16
8-6.2.3	High-Pressure Air Cylinders and Flasks.	8-19
8-6.2.4	Shipboard Air Systems.	8-20
8-7	DIVER COMMUNICATIONS	8-20
8-7.1	Diver Intercommunication Systems	8-20
8-7.2	Line-Pull Signals	8-21
8-8	PREDIVE PROCEDURES	8-22
8-8.1	Predive Checklist	8-22
8-8.2	Diving Station Preparation	8-22
8-8.3	Air Supply Preparation	8-23
8-8.4	Line Preparation	8-23
8-8.5	Recompression Chamber Inspection and Preparation	8-24
8-8.6	Predive Inspection	8-24
8-8.7	Donning Gear	8-24
8-8.8	Diving Supervisor Predive Checklist	8-24
8-9	WATER ENTRY AND DESCENT	8-24
8-9.1	Predescent Surface Check	8-24
8-9.2	Descent.	8-25
8-10	UNDERWATER PROCEDURES	8-26
8-10.1	Adapting to Underwater Conditions	8-26
8-10.2	Movement on the Bottom	8-26
8-10.3	Searching on the Bottom	8-27
8-10.4	Enclosed Space Diving.	8-27
8-10.4.1	Enclosed Space Hazards	8-27
8-10.4.2	Enclosed Space Safety Precautions	8-28

Chap/Para		Page
8-10.5	Working Around Corners	8-28
8-10.6	Working Inside a Wreck	8-28
8-10.7	Working With or Near Lines or Moorings	8-29
8-10.8	Bottom Checks	8-29
8-10.9	Job Site Procedures	8-29
8-10.9.1	Underwater Ship Husbandry Procedures.	8-29
8-10.9.2	Working with Tools.	8-30
8-10.10	Safety Procedures	8-30
8-10.10.1	Fouled Umbilical Lines.	8-30
8-10.10.2	Fouled Descent Lines	8-31
8-10.10.3	Falling.	8-31
8-10.10.4	Damage to Helmet and Diving Dress.	8-31
8-10.11	Tending the Diver	8-31
8-10.12	Monitoring the Diver's Movements	8-32
8-11	ASCENT PROCEDURES	8-32
8-12	SURFACE DECOMPRESSION.	8-33
8-12.1	Disadvantages of In-Water Decompression	8-33
8-12.2	Transferring a Diver to the Chamber	8-34
8-13	POSTDIVE PROCEDURES	8-34
8-13.1	Personnel and Reporting	8-34
8-13.2	Equipment	8-35
9	AIR DECOMPRESSION	
9-1	INTRODUCTION	9-1
9-1.1	Purpose	9-1
9-1.2	Scope	9-1
9-2	THEORY OF DECOMPRESSION	9-1
9-3	AIR DECOMPRESSION DEFINITIONS	9-2
9-3.1	Descent Time	9-2
9-3.2	Bottom Time	9-2
9-3.3	Decompression Table.	9-2
9-3.4	Decompression Schedule.	9-2
9-3.5	Decompression Stop	9-2
9-3.6	Depth.	9-2
9-3.7	Equivalent Single Dive Bottom Time	9-3
9-3.8	Unlimited/No-Decompression (No "D") Limit	9-3
9-3.9	Repetitive Dive	9-3

Chap/Para		Page
9-3.10	Repetitive Group Designation	9-3
9-3.11	Residual Nitrogen	9-3
9-3.12	Residual Nitrogen Time	9-3
9-3.13	Single Dive	9-3
9-3.14	Single Repetitive Dive	9-3
9-3.15	Surface Interval	9-3
9-4	DIVE RECORDING	9-3
9-5	TABLE SELECTION	9-5
9-5.1	Decompression Tables Available	9-5
9-5.2	Selection of Decompression Schedule	9-6
9-6	ASCENT PROCEDURES	9-7
9-6.1	Rules During Ascent	9-7
9-6.1.1	Ascent Rate	9-7
9-6.1.2	Decompression Stop Time	9-7
9-6.2	Variations in Rate of Ascent	9-8
9-6.2.1	Delays in Arriving at the First Stop	9-8
9-6.2.2	Travel Rate Exceeded	9-11
9-7	UNLIMITED/NO-DECOMPRESSION LIMITS AND REPETITIVE GROUP DESIGNATION TABLE FOR UNLIMITED/NO-DECOMPRESSION AIR DIVES	9-11
9-7.1	Example	9-11
9-7.2	Solution	9-11
9-8	U.S. NAVY STANDARD AIR DECOMPRESSION TABLE	9-12
9-8.1	Example	9-12
9-8.2	Solution	9-14
9-9	REPETITIVE DIVES	9-14
9-9.1	Residual Nitrogen Timetable for Repetitive Air Dives	9-14
9-9.1.1	Example	9-18
9-9.1.2	RNT Exception Rule	9-22
9-10	SURFACE DECOMPRESSION	9-22
9-10.1	Surface Decompression Table Using Oxygen	9-22
9-10.1.1	Example	9-23
9-10.1.2	Oxygen System Failure (40-fsw Chamber Stop)	9-23
9-10.1.3	CNS Oxygen Toxicity (40-fsw Chamber Stop)	9-25
9-10.1.4	Convulsions at the 40-fsw Chamber Stop	9-25
9-10.1.5	Repetitive Dives	9-27
9-10.2	Surface Decompression Table Using Air	9-28
9-10.2.1	Example	9-28
9-10.2.2	Solution	9-28

Chap/Para	Page
9-10.2.3 Repetitive Dives	9-28
9-11 EXCEPTIONAL EXPOSURE DIVES	9-34
9-11.1 Surface Decompression Procedures for Exceptional Exposure Dives.	9-34
9-11.1.1 If oxygen is available at the 30 fsw stop in the water:	9-34
9-11.1.2 If no oxygen is available at the 30 fsw stop in the water:	9-38
9-11.2 Oxygen System Failure (Chamber Stop)	9-38
9-12 DIVING AT HIGH ALTITUDES	9-39
9-12.1 Altitude Correction Procedure.	9-39
9-12.1.1 Correction of Depth of Dive.	9-39
9-12.1.2 Correction for Decompression Stop Depths.	9-39
9-12.2 Need for Correction.	9-40
9-12.3 Depth Measurement at Altitude.	9-40
9-12.4 Equilibration at Altitude.	9-40
9-12.5 Diving At Altitude Worksheet.	9-42
9-12.5.1 Corrections for Depth of Dive at Altitude and In-Water Stops.	9-42
9-12.5.2 Corrections for Equilibration.	9-43
9-12.6 Repetitive Dives.	9-45
9-13 ASCENT TO ALTITUDE AFTER DIVING/FLYING AFTER DIVING.	9-49
 10 NITROGEN-OXYGEN DIVING OPERATIONS	
10-1 INTRODUCTION	10-1
10-1.1 Advantages and Disadvantages of NITROX Diving	10-1
10-2 EQUIVALENT AIR DEPTH	10-1
10-2.1 Equivalent Air Depth Calculation	10-2
10-3 OXYGEN TOXICITY	10-2
10-3.1 Selecting the Proper NITROX Mixture	10-3
10-4 NITROX DIVING PROCEDURES	10-3
10-4.1 NITROX Diving Using Equivalent Air Depths	10-3
10-4.2 Scuba Operations.	10-4
10-4.3 Special Procedures.	10-5
10-4.4 Omitted Decompression.	10-5
10-4.5 Dives Exceeding the Normal Working Limit	10-5
10-5 NITROX REPETITIVE DIVING	10-5
10-6 NITROX DIVE CHARTING	10-5
10-7 FLEET TRAINING FOR NITROX	10-7

Chap/Para	Page
10-8 NITROX DIVING EQUIPMENT	10-7
10-8.1 Open-Circuit Scuba Systems	10-7
10-8.1.1 Regulators	10-7
10-8.1.2 Bottles.	10-8
10-8.2 General	10-8
10-8.3 Surface-Supplied NITROX Diving.	10-8
10-9 EQUIPMENT CLEANLINESS	10-8
10-10 BREATHING GAS PURITY	10-9
10-11 NITROX MIXING	10-9
10-12 NITROX MIXING, BLENDING, AND STORAGE SYSTEMS	10-12
 11 ICE AND COLD WATER DIVING OPERATIONS	
11-1 INTRODUCTION	11-1
11-1.1 Purpose.	11-1
11-1.2 Scope.	11-1
11-2 OPERATIONS PLANNING	11-1
11-2.1 Planning Guidelines	11-1
11-2.2 Navigational Considerations	11-1
11-2.3 Scuba Considerations.	11-2
11-2.4 Scuba Regulators.	11-2
11-2.4.1 Special Precautions.	11-3
11-2.4.2 Octopus and Redundant Regulators	11-3
11-2.5 Life Preserver	11-3
11-2.6 Face Mask	11-4
11-2.7 Scuba Equipment	11-4
11-2.8 Surface-Supplied Diving System (SSDS) Considerations	11-4
11-2.8.1 Advantages and Disadvantages of SSDS.	11-4
11-2.8.2 Effect of Ice Conditions on SSDS.	11-5
11-2.9 Suit Selection	11-5
11-2.9.1 Wet Suits	11-5
11-2.9.2 Variable Volume Dry Suits	11-6
11-2.9.3 Extreme Exposure Suits/Hot Water Suits.	11-6
11-2.10 Clothing.	11-6
11-2.11 Ancillary Equipment	11-7
11-2.12 Dive Site Shelter	11-7
11-3 PREDIVE PROCEDURES	11-7
11-3.1 Personnel Considerations.	11-7

Chap/Para		Page
11-3.2	Dive Site Selection Considerations.	11-7
11-3.3	Shelter	11-8
11-3.4	Entry Hole.	11-8
11-3.5	Escape Holes.	11-8
11-3.6	Navigation Lines.	11-8
11-3.7	Lifelines	11-8
11-3.8	Equipment Preparation.	11-9
11-4	UNDERWATER PROCEDURES	11-9
11-4.1	Buddy Diving	11-9
11-4.2	Tending the Diver	11-10
11-4.3	Standby Diver	11-10
11-5	OPERATING PRECAUTIONS	11-10
11-5.1	General Precautions.	11-10
11-5.2	Ice Conditions.	11-11
11-5.3	Dressing Precautions	11-11
11-5.4	On-Surface Precautions.	11-11
11-5.5	In-Water Precautions.	11-12
11-5.6	Postdive Precautions	11-12
11-6	EMERGENCY PROCEDURES	11-13
11-6.1	Lost Diver	11-13
11-6.2	Searching for a Lost Diver	11-13
11-6.3	Hypothermia	11-13
11-7	ADDITIONAL REFERENCES	11-14

Mixed-Gas Surface-Supplied Diving Operations

12	Mixed-Gas Diving Theory
13	Mixed-Gas Operational Planning
14	Surface-Supplied Mixed-Gas Diving Procedures
15	Saturation Diving
16	Breathing Gas Mixing Procedures



Volume 3 - Table of Contents

Chap/Para		Page
12	MIXED-GAS DIVING THEORY	
12-1	INTRODUCTION	12-1
12-1.1	Purpose.	12-1
12-1.2	Scope.	12-1
12-2	BOYLE'S LAW	12-1
12-3	CHARLES'/GAY-LUSSAC'S LAW	12-4
12-4	THE GENERAL GAS LAW	12-7
12-5	DALTON'S LAW	12-11
12-6	HENRY'S LAW	12-14
13	MIXED-GAS OPERATIONAL PLANNING	
13-1	INTRODUCTION	13-1
13-1.1	Purpose.	13-1
13-1.2	Scope.	13-1
13-1.3	Additional Sources of Information..	13-1
13-1.4	Complexity of Mixed-Gas Diving.	13-1
13-1.5	Medical Considerations	13-1
13-2	ESTABLISH OPERATIONAL TASKS	13-2
13-3	SELECT DIVING METHOD AND EQUIPMENT	13-2
13-3.1	Mixed-Gas Diving Methods	13-3
13-3.2	Method Considerations	13-3
13-3.3	Depth	13-3
13-3.4	Bottom Time Requirements	13-4
13-3.5	Environment	13-4
13-3.6	Mobility.	13-5
13-3.7	Equipment Selection..	13-5
13-3.8	Operational Characteristics.	13-6
13-3.9	Support Equipment and ROVs	13-6
13-3.9.1	Types of ROV..	13-7
13-3.9.2	ROV Capabilities.	13-7
13-3.10	Diver's Breathing Gas Requirements	13-8
13-3.10.1	Gas Consumption Rates	13-8

Chap/Para		Page
	13-3.10.2 Surface-Supplied Diving Requirements.....	13-8
	13-3.10.3 Deep Diving System Requirements.....	13-8
13-4	SELECTING AND ASSEMBLING THE DIVE TEAM	13-8
13-4.1	Diver Training	13-8
13-4.2	Personnel Requirements.	13-9
13-4.3	Diver Fatigue.	13-9
13-5	BRIEFING THE DIVE TEAM	13-9
13-6	FINAL PREPARATIONS AND SAFETY PRECAUTIONS.	13-11
13-7	RECORD KEEPING.	13-11
13-8	MIXED-GAS DIVING EQUIPMENT	13-11
13-8.1	Minimum Required Equipment.	13-12
13-8.2	MK 21 MOD 1 Lightweight Surface-Supplied Helium-Oxygen Description	13-12
13-8.3	Flyaway Dive System III Mixed Gas System (FMGS).....	13-13
14	SURFACE-SUPPLIED MIXED-GAS DIVING PROCEDURES	
14-1	INTRODUCTION	14-1
14-1.1	Purpose.	14-1
14-1.2	Scope.....	14-1
14-2	PLANNING THE OPERATION	14-1
14-2.1	Depth and Exposure Time	14-1
14-2.2	Water Temperature	14-1
14-2.3	Gas Mixtures	14-1
14-2.3.1	Maximum/Minimum Mixtures.....	14-2
14-2.3.2	Emergency Gas Supply.....	14-2
14-3	SURFACE-SUPPLIED HELIUM-OXYGEN DESCENT AND ASCENT PROCEDURES	14-2
14-3.1	Surface-Supplied Helium-Oxygen Decompression Table.....	14-3
14-3.1.1	Calculating Maximum Depth.	14-3
14-3.1.2	Travel Rates.	14-4
14-3.1.3	Decompression Breathing Gas.	14-4
14-3.2	Special Procedures for Descent with Less than 16 percent Oxygen	14-4
14-3.2.1	Descent Procedure.	14-4
14-3.2.2	Aborting the Dive.	14-4
14-3.3	Procedures for Shifting to 60 Percent Helium/40 Percent Oxygen at 100 fsw.....	14-5
14-3.4	Procedures for Shifting to 100 Percent Oxygen at the First Oxygen Stop. . .	14-5
14-3.5	Ascent from the 40-fsw Water Stop.	14-5

Chap/Para		Page
14-3.6	Surface Decompression Procedures (SUR D)	14-5
14-3.7	Normal SUR D Procedures Using Oxygen	14-8
14-3.7.1	Initiating Normal Surface Decompression.	14-8
14-3.8	Emergency SUR D Procedures Using Oxygen	14-11
14-3.9	Aborted Dive During Descent	14-11
14-3.9.1	Dive Aborted at 200 fsw or Shallower.	14-11
14-3.9.2	Dive Aborted Deeper than 200 fsw.	14-11
14-3.9.3	No-Decompression Limits.	14-11
14-3.10	Variation in Rate of Ascent	14-14
14-3.10.1	Early Arrival at the First Stop	14-14
14-3.10.2	Delays in Arriving at the First Stop.	14-14
14-3.10.3	Delays in Leaving a Stop	14-15
14-3.10.4	Delays in Travel from 40 fsw to the Surface	14-15
14-3.11	Special Procedures for Diving with an Oxygen Partial Pressure Greater Than 1.3 ata.	14-15
14-3.11.1	Calculating Oxygen Partial Pressure	14-15
14-3.11.2	Gas Mixtures.	14-17
14-3.11.3	Charting Surface-Supplied Helium-Oxygen Dives	14-17
14-4	SURFACE-SUPPLIED HELIUM-OXYGEN EMERGENCY PROCEDURES	14-17
14-4.1	Bottom Time in Excess of the Table	14-17
14-4.2	Loss of Helium-Oxygen Supply on the Bottom	14-17
14-4.3	Inability to Shift to 40 Percent Oxygen at 100 fsw During Decompression . .	14-19
14-4.4	Loss of Oxygen Supply at 50 fsw	14-19
14-4.4.1	Unable to Shift to 60/40.	14-19
14-4.4.2	Surface Decompression from the Emergency Procedures Decompression Table.	14-20
14-4.5	Loss of Oxygen Supply at the 40-fsw Stop	14-20
14-4.5.1	Oxygen Lost before Diver is within Emergency SUR D Limits.	14-20
14-4.5.2	Diver is within Emergency SUR D Limits.	14-20
14-4.5.3	Diver is within Normal SUR D Limits.	14-20
14-4.5.4	Diver is in the Chamber.	14-20
14-4.6	Oxygen Supply Contaminated with Helium-Oxygen	14-21
14-4.7	Central Nervous System (CNS) Oxygen Toxicity Symptoms (Nonconvulsive) at the 50-fsw Stop.	14-21
14-4.8	CNS Oxygen Toxicity Symptoms (Nonconvulsive) at the 40-fsw Stop	14-22
14-4.8.1	Diver is not within Emergency Surface Decompression Limits.	14-22
14-4.8.2	Diver is within Emergency Surface Decompression Limits.	14-22
14-4.8.3	Diver is within Normal Surface Decompression Limits.	14-22
14-4.8.4	Diver is at a Chamber Stop.	14-22
14-4.9	CNS Oxygen Convulsion at the 50-fsw Stop or 40-fsw Stop.	14-22
14-4.10	Omitted Decompression	14-23
14-4.10.1	Blowup from a Depth Greater Than 50 fsw.	14-23

Chap/Para		Page
	14-4.10.2 For Saturation Systems.	14-24
	14-4.10.3 For Nonsaturation Systems.	14-24
14-4.11	Light-Headed or Dizzy Diver on the Bottom	14-26
	14-4.11.1 Initial Treatment.	14-26
	14-4.11.2 Vertigo.	14-26
14-4.12	Unconscious Diver on the Bottom.	14-26
14-4.13	Decompression Sickness in the Water	14-28
	14-4.13.1 Management.	14-28
	14-4.13.2 Deeper than 50 fsw.	14-28
	14-4.13.3 At 50 fsw and Shallower.	14-28
	14-4.13.4 Resolution/Nonresolution.	14-28
15	SATURATION DIVING	
15-1	INTRODUCTION	15-1
	15-1.1 Purpose.	15-1
	15-1.2 Scope.	15-1
15-2	APPLICATIONS.	15-1
15-3	BASIC COMPONENTS OF A SATURATION DIVE SYSTEM.	15-1
	15-3.1 Personnel Transfer Capsule	15-1
	15-3.1.1 Gas Supplies	15-1
	15-3.1.2 PTC Pressurization/Depressurization System.	15-2
	15-3.1.3 PTC Life-Support System.	15-3
	15-3.1.4 Electrical System.	15-3
	15-3.1.5 Communications System	15-3
	15-3.1.6 Strength, Power, and Communications Cables (SPCCs).	15-3
	15-3.1.7 PTC Main Umbilical.	15-3
	15-3.1.8 Diver Hot Water System.	15-3
	15-3.2 Deck Decompression Chamber (DDC).	15-3
	15-3.2.1 DDC Life-Support System (LSS).	15-4
	15-3.2.2 Sanitary System.	15-4
	15-3.2.3 Fire Suppression System	15-4
	15-3.2.4 Main Control Console (MCC).	15-4
	15-3.2.5 Gas Supply Mixing and Storage	15-4
	15-3.3 PTC Handling Systems	15-4
	15-3.3.1 Handling System Characteristics.	15-5
	15-3.4 Saturation Mixed-Gas Diving Equipment	15-5
15-4	U.S. NAVY SATURATION FACILITIES	15-5
	15-4.1 Navy Experimental Diving Unit (NEDU), Panama City, FL	15-5
	15-4.2 Naval Submarine Medical Research Laboratory (NSMRL), New London, CT	15-6
15-5	INTRODUCTION	15-6

Chap/Para		Page
15-6	THERMAL PROTECTION SYSTEM	15-9
15-6.1	Diver Heating.	15-9
15-6.2	Inspired Gas Heating.	15-9
15-7	SATURATION DIVING UNDERWATER BREATHING APPARATUS	15-10
15-8	UBA GAS USAGE	15-11
15-8.1	Specific Dives.	15-11
15-8.2	Emergency Gas Supply Duration	15-12
15-8.3	Gas Composition.	15-13
15-9	INTRODUCTION	15-14
15-10	OPERATIONAL CONSIDERATIONS	15-14
15-10.1	Dive Team Selection	15-14
15-10.2	Mission Training.	15-14
15-11	SELECTION OF STORAGE DEPTH	15-15
15-12	RECORDS	15-16
15-12.1	Command Diving Log	15-16
15-12.2	Master Protocol	15-16
15-12.2.1	Modifications.	15-16
15-12.2.2	Elements.	15-16
15-12.3	Chamber Atmosphere Data Sheet	15-16
15-12.4	Service Lock	15-17
15-12.5	Machinery Log/Gas Status Report	15-17
15-12.6	Operational Procedures (OPs)	15-17
15-12.7	Emergency Procedures (EPs).	15-17
15-12.8	Individual Dive Record.	15-17
15-13	LOGISTICS	15-17
15-14	DDC AND PTC ATMOSPHERE CONTROL	15-18
15-15	GAS SUPPLY REQUIREMENTS	15-18
15-15.1	UBA Gas	15-19
15-15.2	Emergency Gas.	15-19
15-15.3	Treatment Gases.	15-19
15-16	ENVIRONMENTAL CONTROL	15-19
15-17	FIRE ZONE CONSIDERATIONS	15-20
15-18	HYGIENE	15-21
15-18.1	Personal Hygiene.	15-21

Chap/Para		Page
15-18.2	Prevention of External Ear Infections	15-21
15-18.3	Chamber Cleanliness.	15-22
15-18.4	Food Preparation and Handling.	15-22
15-19	ATMOSPHERE QUALITY CONTROL	15-22
15-19.1	Gaseous Contaminants.	15-22
15-19.2	Initial Unmanned Screening Procedures.	15-22
15-20	COMPRESSION PHASE	15-24
15-20.1	Establishing Chamber Oxygen Partial Pressure.	15-24
15-20.2	Compression to Storage Depth.	15-24
15-20.3	Precautions During Compression.	15-25
15-20.4	Abort Procedures During Compression.	15-25
15-21	STORAGE DEPTH	15-25
15-21.1	Excursion Table Examples.	15-28
15-21.2	PTC Diving Procedures.	15-29
	15-21.2.1 PTC Deployment Procedures.	15-29
15-22	DEEP DIVING SYSTEM (DDS) EMERGENCY PROCEDURES	15-31
15-22.1	Loss of Chamber Atmosphere Control.	15-31
	15-22.1.1 Loss of Oxygen Control	15-31
	15-22.1.2 Loss of Carbon Dioxide Control	15-31
	15-22.1.3 Atmosphere Contamination	15-31
	15-22.1.4 Interpretation of the Analysis.	15-31
	15-22.1.5 Loss of Temperature Control	15-32
15-22.2	Loss of Depth Control	15-32
15-22.3	Fire in the DDC.	15-32
15-22.4	PTC Emergencies.	15-33
15-23	SATURATION DECOMPRESSION	15-33
15-23.1	Upward Excursion Depth.	15-33
15-23.2	Travel Rate.	15-33
15-23.3	Post-Excursion Hold.	15-33
15-23.4	Rest Stops.	15-33
15-23.5	Saturation Decompression Rates.	15-34
15-23.6	Atmosphere Control at Shallow Depths.	15-34
15-23.7	Saturation Dive Mission Abort.	15-35
	15-23.7.1 Emergency Cases.	15-35
	15-23.7.2 Emergency Abort Procedure.	15-36
15-23.8	Decompression Sickness (DCS).	15-37
	15-23.8.1 Type I Decompression Sickness	15-37
	15-23.8.2 Type II Decompressions Sickness	15-39

Chap/Para		Page
15-24	POSTDIVE PROCEDURES	15-39
16	BREATHING GAS MIXING PROCEDURES	
16-1	INTRODUCTION	16-1
16-1.1	Purpose.	16-1
16-1.2	Scope.	16-1
16-2	MIXING PROCEDURES	16-1
16-2.1	Mixing by Partial Pressure.	16-1
16-2.2	Ideal-Gas Method Mixing Procedure	16-2
16-2.3	Adjustment of Oxygen Percentage.....	16-5
16-2.3.1	Increasing the Oxygen Percentage.....	16-5
16-2.3.2	Reducing the Oxygen Percentage	16-6
16-2.4	Continuous-Flow Mixing	16-7
16-2.5	Mixing by Volume	16-7
16-2.6	Mixing by Weight	16-8
16-3	GAS ANALYSIS	16-8
16-3.1	Instrument Selection.....	16-9
16-3.2	Techniques for Analyzing Constituents of a Gas.....	16-9

Page Left Blank Intentionally

Closed-Circuit and Semiclosed-Circuit Diving Operations

17	Closed-Circuit Mixed- Gas UBA Diving
18	Closed-Circuit Oxygen UBA Diving



Volume 4 - Table of Contents

Chap/Para		Page
17	CLOSED-CIRCUIT MIXED-GAS UBA DIVING	
17-1	INTRODUCTION	17-1
17-1.1	Purpose.	17-1
17-1.2	Scope.	17-1
17-2	PRINCIPLES OF OPERATION	17-1
17-2.1	Recirculation and Carbon Dioxide Removal	17-2
17-2.1.1	Recirculating Gas.	17-2
17-2.1.2	Full Face Mask.	17-2
17-2.1.3	Carbon Dioxide Scrubber	17-3
17-2.1.4	Diaphragm Assembly	17-3
17-2.1.5	Recirculation System	17-3
17-2.2	Gas Addition, Exhaust, and Monitoring.	17-4
17-2.3	Advantages of Closed-Circuit Mixed-Gas UBA.	17-5
17-3	USN CLOSED-CIRCUIT MIXED-GAS UBA	17-5
17-3.1	Diving Safety.	17-5
17-3.2	MK 16 UBA Basic Systems.	17-5
17-3.3	Housing System.	17-5
17-3.4	Recirculation System.	17-6
17-3.4.1	Closed-Circuit Subassembly.	17-6
17-3.4.2	Scrubber Functions.	17-6
17-3.5	Pneumatics System.	17-6
17-3.6	Electronics System.	17-6
17-3.6.1	Oxygen Sensing.	17-7
17-3.6.2	Oxygen Control.	17-7
17-3.6.3	Displays.	17-7
17-4	OPERATIONAL PLANNING	17-8
17-4.1	Operating Limitations.	17-9
17-4.1.1	Oxygen Flask Endurance	17-9
17-4.1.2	Diluent Flask Endurance.	17-12
17-4.1.3	Canister Duration	17-12
17-4.1.4	Thermal Protection.	17-13
17-4.2	Equipment Requirements	17-13
17-4.2.1	Distance Line.	17-14
17-4.2.2	Standby Diver	17-14
17-4.2.3	Lines.	17-14
17-4.2.4	Marking of Lines.	17-14
17-4.2.5	Diver Marker Buoy.	17-15
17-4.2.6	Depth Gauge/Wrist Watch.	17-15

Chap/Para		Page
17-4.3	Recompression Chamber Considerations.	17-15
17-4.4	Diving Procedures for MK 16.	17-15
17-4.4.1	Employing a Single, Untended EOD Diver.	17-15
17-4.4.2	Simulated Training Scenarios.	17-16
17-4.4.3	EOD Standard Safety Procedures	17-16
17-4.4.4	Diving Methods.	17-16
17-4.5	Ship Safety.	17-17
17-4.6	Operational Area Clearance.	17-17
17-5	PREDIVE PROCEDURES	17-17
17-5.1	Diving Supervisor Brief	17-17
17-5.2	Diving Supervisor Check.	17-17
17-6	WATER ENTRY AND DESCENT	17-19
17-7	UNDERWATER PROCEDURES	17-19
17-7.1	General Guidelines	17-19
17-7.2	At Depth.	17-19
17-8	ASCENT PROCEDURES	17-21
17-9	POSTDIVE PROCEDURES	17-21
17-10	DECOMPRESSION PROCEDURES	17-21
17-10.1	Use of Constant ppO ₂ Decompression Tables.	17-21
17-10.2	Monitoring ppO ₂	17-21
17-10.3	Rules for Using 0.7 ata Constant ppO ₂ in Nitrogen and in Helium Decompression Tables.	17-22
17-10.4	PPO ₂ Variances.	17-23
17-10.5	Emergency Breathing System (EBS)	17-29
17-10.5.1	EBS Type I.	17-29
17-10.5.2	EBS Type II MK 1 Mod 0.	17-29
17-10.5.3	Required Gas Supply for the EBS	17-29
17-10.5.4	EBS Deployment Procedures.	17-35
17-10.6	Omitted Decompression	17-35
17-10.6.1	At 20 fsw or Shallower.	17-35
17-10.6.2	Deeper than 20 fsw.	17-36
17-10.6.3	Deeper than 20 fsw/No Recompression Chamber Available.	17-37
17-10.6.4	Evidence of Decompression Sickness or Arterial Gas Embolism.	17-37
17-11	MEDICAL ASPECTS OF CLOSED-CIRCUIT MIXED-GAS UBA	17-37
17-11.1	Central Nervous System (CNS) Oxygen Toxicity.	17-37
17-11.1.1	Preventing CNS Oxygen Toxicity	17-37
17-11.1.2	Symptoms of CNS Oxygen Toxicity	17-38
17-11.1.3	Treating Nonconvulsive Symptoms of CNS Oxygen Toxicity	17-38

Chap/Para	Page
17-11.1.4	Treating CNS Oxygen Toxicity Convulsions17-38
17-11.2	Oxygen Deficiency (Hypoxia) 17-39
17-11.2.1	Causes of Hypoxia17-39
17-11.2.2	Symptoms of Hypoxia17-39
17-11.2.3	Treating Hypoxia.17-39
17-11.2.4	Treatment of Hypoxic Divers Requiring Decompression17-39
17-11.3	Carbon Dioxide Toxicity (Hypercapnia) 17-39
17-11.3.1	Symptoms of Hypercapnia17-40
17-11.3.2	Treating Hypercapnia17-40
17-11.4	Chemical Injury 17-40
17-11.4.1	Causes of Chemical Injury17-40
17-11.4.2	Symptoms of Chemical Injury17-40
17-11.4.3	Management of a Chemical Incident.17-40
17-11.5	Decompression Sickness in the Water 17-41
17-11.5.1	Diver Remaining in Water.17-41
17-11.5.2	Diver Leaving the Water.. . . .17-42
18	CLOSED-CIRCUIT OXYGEN UBA DIVING
18-1	INTRODUCTION 18-1
18-1.1	Purpose. 18-1
18-1.2	Scope. 18-1
18-2	MEDICAL ASPECTS OF CLOSED-CIRCUIT OXYGEN DIVING 18-1
18-2.1	Oxygen Toxicity. 18-2
18-2.1.1	Off-Effect.18-2
18-2.1.2	Pulmonary Oxygen Toxicity18-2
18-2.1.3	Symptoms of CNS Oxygen Toxicity18-2
18-2.1.4	Causes of CNS Oxygen Toxicity.18-3
18-2.1.5	Treatment of Nonconvulsive Symptoms18-4
18-2.1.6	Treatment of Underwater Convulsion18-4
18-2.2	Oxygen Deficiency (Hypoxia) 18-4
18-2.2.1	Causes of Hypoxia with the MK 25 UBA.18-5
18-2.2.2	Underwater Purge.18-5
18-2.2.3	MK 25 UBA Purge Procedure.18-5
18-2.2.4	Symptoms of Hypoxia18-5
18-2.2.5	Treatment of Hypoxia18-6
18-2.3	Carbon Dioxide Toxicity (Hypercapnia) 18-6
18-2.3.1	Symptoms of Hypercapnia18-6
18-2.3.2	Treating Hypercapnia18-6
18-2.3.3	Avoiding Hypercapnia18-7
18-2.4	Chemical Injury 18-7
18-2.4.1	Causes of Chemical Injury18-7
18-2.4.2	Symptoms of Chemical Injury18-7
18-2.4.3	Management of a Chemical Incident.18-8

Chap/Para		Page
18-2.5	Middle Ear Oxygen Absorption Syndrome	18-8
18-2.5.1	Symptoms of Middle Ear Oxygen Absorption Syndrome	18-8
18-2.5.2	Treating Middle Ear Oxygen Absorption Syndrome	18-9
18-3	MK 25 (DRAEGER LAR V UBA)	18-9
18-3.1	Gas Flow Path.	18-9
18-3.1.1	Breathing Loop.	18-10
18-3.2	Operational Duration of the MK 25 UBA	18-11
18-3.2.1	Oxygen Supply	18-11
18-3.2.2	Canister Duration	18-11
18-3.3	Packing Precautions.	18-12
18-3.4	Preventing Caustic Solutions in the Canister.	18-12
18-3.5	References.	18-12
18-4	CLOSED-CIRCUIT OXYGEN EXPOSURE LIMITS	18-13
18-4.1	Transit with Excursion Limits Table.	18-13
18-4.2	Single-Depth Oxygen Exposure Limits Table.	18-13
18-4.3	Oxygen Exposure Limit Testing.	18-13
18-4.4	Individual Oxygen Susceptibility Precautions.	18-13
18-4.5	Transit with Excursion Limits.	18-14
18-4.5.1	Transit with Excursion Limits Definitions	18-14
18-4.5.2	Transit with Excursion Rules	18-15
18-4.5.3	Inadvertent Excursions	18-15
18-4.6	Single-Depth Limits.	18-16
18-4.6.1	Single-Depth Limits Definitions.	18-16
18-4.6.2	Depth/Time Limits.	18-16
18-4.7	Exposure Limits for Successive Oxygen Dives	18-16
18-4.7.1	Definitions for Successive Oxygen Dives.	18-16
18-4.7.2	Off-Oxygen Exposure Limit Adjustments.	18-17
18-4.8	Exposure Limits for Oxygen Dives Following Mixed-Gas or Air Dives	18-18
18-4.8.1	Mixed-Gas to Oxygen Rule.	18-18
18-4.8.2	Oxygen to Mixed-Gas Rule.	18-18
18-4.9	Oxygen Diving at High Elevations.	18-18
18-4.10	Flying After Oxygen Diving	18-18
18-4.11	Combat Operations	18-18
18-4.12	References for Additional Information.	18-18
18-5	OPERATIONS PLANNING	18-19
18-5.1	Operating Limitations	18-19
18-5.2	Maximizing Operational Range	18-19
18-5.3	Training	18-20
18-5.4	Personnel Requirements.	18-20

Chap/Para		Page
18-5.5	Equipment Requirements	18-21
18-5.6	Transport and Storage of Prepared UBA.	18-21
18-5.7	Predive Precautions	18-22
18-6	PREDIVE PROCEDURES	18-23
18-6.1	Equipment Preparation	18-23
18-6.2	Diving Supervisor Brief	18-23
18-6.3	Diving Supervisor Check	18-23
	18-6.3.1 First Phase.	18-23
	18-6.3.2 Second Phase.	18-23
18-7	WATER ENTRY AND DESCENT	18-24
18-7.1	Purge Procedure	18-24
18-7.2	Turtleback Emergency Descent Procedure.	18-25
18-7.3	Avoiding Purge Procedure Errors	18-25
18-7.4	References for Additional Information.	18-25
18-8	UNDERWATER PROCEDURES	18-26
18-8.1	General Guidelines.	18-26
18-8.2	UBA Malfunction Procedures.	18-27
18-9	ASCENT PROCEDURES.	18-27
18-10	POSTDIVE PROCEDURES AND DIVE DOCUMENTATION	18-27

Page Left Blank Intentionally

Diving Medicine & Recompression Chamber Operations

19	Diving Disorders Not Requiring Recompression Therapy
20	Diving Disorders Requiring Recompression Therapy
21	Recompression Therapy
22	Recompression Chamber Operation
Appendix 5A	Neurological Examination
Appendix 5B	First Aid
Appendix 5C	Dangerous Marine Animals



Volume 5 - Table of Contents

Chap/Para		Page
19	DIVING DISORDERS NOT REQUIRING RECOMPRESSION THERAPY	
19-1	INTRODUCTION	19-1
19-1.1	Purpose.	19-1
19-1.2	Scope.	19-1
19-2	BREATHING GAS DISORDERS	19-1
19-2.1	Oxygen Deficiency (Hypoxia)	19-1
19-2.1.1	Causes of Hypoxia	19-2
19-2.1.2	Treating Hypoxia.	19-2
19-2.1.3	Unconsciousness Due to Hypoxia.	19-2
19-2.1.4	Treating Hypoxia in Specific Operational Environments.	19-2
19-2.2	Carbon Monoxide Poisoning.	19-2
19-2.3	Carbon Dioxide Toxicity (Hypercapnia)	19-2
19-2.3.1	Causes of Carbon Dioxide Buildup	19-3
19-2.3.2	Treating Hypercapnia	19-3
19-2.3.3	Treating Hypercapnia in Specific Operational Environments.	19-3
19-2.4	Oxygen Toxicity.	19-3
19-2.4.1	Central Nervous System (CNS) Oxygen Toxicity.	19-3
19-2.4.2	Symptoms of CNS Oxygen Toxicity	19-4
19-2.4.3	Treating a Tethered Diver	19-4
19-2.4.4	Treating a Free-Swimming Diver	19-4
19-2.4.5	Treatment for CNS Convulsions	19-4
19-2.4.6	Treating CNS Oxygen Toxicity in Specific Operational Environments.	19-5
19-2.5	Nitrogen Narcosis.	19-5
19-2.5.1	Symptoms of Nitrogen Narcosis.	19-5
19-2.5.2	Treatment of Nitrogen Narcosis.	19-5
19-2.5.3	Nitrogen Narcosis in MK 16.	19-5
19-2.6	Hyperventilation.	19-5
19-2.7	Shortness of Breath (Dyspnea)	19-5
19-3	PULMONARY OVERINFLATION SYNDROMES	19-6
19-3.1	Mediastinal and Subcutaneous Emphysema	19-6
19-3.1.1	Causes of Subcutaneous Emphysema.	19-6
19-3.1.2	Treatment of Mediastinal and Subcutaneous Emphysema.	19-6
19-3.2	Pneumothorax	19-7
19-3.2.1	Symptoms of Pneumothorax.	19-7
19-3.2.2	Treating Pneumothorax.	19-7
19-3.3	Prevention of Pulmonary Overinflation Syndrome.	19-7
19-4	BAROTRAUMA	19-8

Chap/Para		Page
19-4.1	Squeeze.....	19-8
19-4.1.1	Treating Squeeze During Descent	19-9
19-4.1.2	Treating Reverse Squeeze During Ascent	19-9
19-4.1.3	Preventing Squeeze	19-9
19-4.2	Gastrointestinal Distention as a Result of Gas Expansion	19-10
19-4.2.1	Treating Intestinal Gas Expansion.....	19-10
19-4.2.2	Preventing Intestinal Gas Expansion	19-10
19-4.3	Ear Barotrauma.	19-10
19-4.3.1	Eardrum Rupture	19-10
19-4.3.2	Inner Ear Barotrauma.....	19-10
19-4.4	Middle Ear Oxygen Absorption Syndrome	19-11
19-4.4.1	Symptoms of Middle Ear Oxygen Absorption Syndrome.....	19-11
19-4.4.2	Treating Middle Ear Oxygen Absorption Syndrome.	19-11
19-5	DISORDERS OF HIGHER FUNCTION AND CONSCIOUSNESS	19-11
19-5.1	Vertigo.	19-11
19-5.1.1	Transient Vertigo.	19-11
19-5.1.2	Persistent Vertigo.	19-12
19-5.2	Unconscious Diver on the Bottom.....	19-12
19-6	NEAR DROWNING	19-13
19-6.1	Causes and Prevention.....	19-13
19-6.1.1	Drowning in Hard-Hat Diving.....	19-13
19-6.1.2	Drowning in Lightweight or Scuba Diving.	19-13
19-6.1.3	Prevention of Drowning.	19-13
19-6.2	Treatment	19-13
19-7	THERMAL STRESS	19-14
19-7.1	Hyperthermia.....	19-14
19-7.1.1	Mild to Moderate Hyperthermia.....	19-14
19-7.1.2	Severe Hyperthermia.....	19-14
19-7.1.3	Cooling Measures.....	19-14
19-7.2	Hypothermia	19-14
19-7.2.1	Mild Hypothermia.....	19-15
19-7.2.2	Severe Hypothermia.	19-15
19-7.2.3	Rewarming Techniques	19-15
19-7.3	Physiological Effects of Exposure to Cold Water	19-15
19-8	OPERATIONAL HAZARDS	19-16
19-8.1	Uncontrolled Ascent	19-16
19-8.2	Otitis Externa.....	19-16
19-8.2.1	External Ear Prophylaxis.....	19-16
19-8.2.2	Occluded External Ear Canal.	19-17
19-8.3	Underwater Trauma	19-17

Chap/Para		Page
19-8.4	Injuries Caused by Marine Life	19-17
19-8.5	Communicable Diseases and Sanitization	19-17
19-9	MEDICATIONS AND DIVING.	19-18
20	DIVING DISORDERS REQUIRING RECOMPRESSION THERAPY	
20-1	INTRODUCTION	20-1
20-1.1	Purpose.	20-1
20-1.2	Scope.	20-1
20-2	ARTERIAL GAS EMBOLISM	20-1
20-2.1	Arterial Embolism Development.	20-1
20-2.2	Unconsciousness Caused by Arterial Gas Embolism.	20-2
20-2.3	Neurological Symptoms of Arterial Gas Embolism.	20-2
20-2.4	Additional Symptoms of Arterial Gas Embolism.	20-2
20-2.5	Neurological Examination Guidelines.	20-2
20-2.6	Administering Advanced Cardiac Life Support (ACLS) in the Embolized Diver	20-3
20-2.7	Prevention of Arterial Gas Embolism.	20-3
20-3	DECOMPRESSION SICKNESS	20-4
20-3.1	Initial Episode of Decompression Sickness.	20-4
20-3.2	Differentiating Type I and Type II Symptoms.	20-5
20-3.3	Type I Decompression Sickness	20-5
20-3.3.1	Musculoskeletal Pain-Only Symptoms.	20-5
20-3.3.2	Cutaneous (Skin) Symptoms.	20-6
20-3.3.3	Lymphatic Symptoms.	20-6
20-3.4	Type II Decompression Sickness	20-6
20-3.4.1	Differentiating Between Type II DCS and AGE.	20-6
20-3.4.2	Type II Symptom Categories.	20-6
20-3.5	Time Course of Symptoms.	20-7
20-3.5.1	Onset of Symptoms.	20-7
20-3.5.2	Dive History.	20-7
20-3.5.3	When Treatment Is Not Necessary.	20-7
20-3.6	Altitude Decompression Sickness	20-8
20-3.6.1	Joint Pain Treatment.	20-8
20-3.6.2	Transfer and Treatment.	20-8
21	RECOMPRESSION THERAPY	
21-1	INTRODUCTION	21-1
21-1.1	Purpose.	21-1

Chap/Para		Page
21-1.2	Scope.	21-1
21-1.3	Diving Supervisor's Responsibilities.. . . .	21-1
21-1.4	Emergency Consultation.	21-1
21-1.5	Applicability of Recompression.	21-2
21-1.6	Recompression Treatment for Non-Diving Disorders.. . . .	21-2
21-1.7	Primary Objectives.. . . .	21-3
21-1.8	Guidance on Recompressed Treatment.	21-4
21-1.9	In-Water or Air Recompression.	21-5
21-2	PRESCRIBING AND MODIFYING TREATMENTS.	21-5
21-3	OMITTED DECOMPRESSION	21-5
21-3.1	Planned and Unplanned Omitted Decompression.. . . .	21-5
21-3.2	Treating Omitted Decompression with Symptoms.. . . .	21-6
21-3.3	Treating Omitted Decompression in Specific Operational Environments.. . .	21-7
21-3.4	Ascent from 20 Feet or Shallower (Shallow Surfacing) with Decompression Stops Required.	21-7
21-3.5	Ascent from 20 Feet or Shallower with No Decompression Stops Required.. . . .	21-7
21-3.6	Ascent from Deeper than 20 Feet (Uncontrolled Ascent)	21-7
21-3.6.1	Asymptomatic Uncontrolled Ascent.. . . .	21-7
21-3.6.2	Development of Symptoms.	21-8
21-3.6.3	In-Water Procedure.	21-8
21-3.6.4	Symptomatic Uncontrolled Ascent.. . . .	21-8
21-4	RECOMPRESSION TREATMENTS WHEN NO RECOMPRESSION CHAMBER IS AVAILABLE.	21-8
21-4.1	Transporting the Patient.	21-9
21-4.1.1	Medical Treatment During Transport.. . . .	21-9
21-4.1.2	Transport by Unpressurized Aircraft.	21-9
21-4.1.3	Communications with Chamber.. . . .	21-9
21-4.2	In-Water Recompression.	21-9
21-4.2.1	Surface Oxygen Treatment.	21-9
21-4.2.2	In-Water Recompression Using Air	21-10
21-4.2.3	In-Water Recompression Using Oxygen	21-10
21-4.2.4	Symptoms After In-Water Recompression.	21-11
21-4.3	Symptoms During Decompression (No Chamber Available).. . . .	21-11
21-5	RECOMPRESSION TREATMENTS WHEN CHAMBER IS AVAILABLE	21-11
21-5.1	Symptoms During Decompression and Surface Decompression (Recompression Chamber Available).. . . .	21-11
21-5.1.1	Treatment During Surface-Supplied HEO ₂ and MK 16 Operations.	21-11
21-5.1.2	Treatment of Symptoms During Sur-D Surface Interval.	21-11
21-5.1.3	Treating for Exceeded Sur-D Surface Interval.. . . .	21-12

Chap/Para		Page
21-5.2	Recompression Treatments When Oxygen Is Not Available.	21-12
21-5.2.1	Descent/Ascent Rates for Air Treatment Tables.	21-12
21-5.3	Treatment at Altitude	21-12
21-5.4	Recompression Treatments When Oxygen Is Available.	21-12
21-5.4.1	Treatment Table 5.	21-12
21-5.4.2	Treatment Table 6.	21-13
21-5.4.3	Treatment Table 6A	21-14
21-5.4.4	Treatment Table 4.	21-14
21-5.4.5	Treatment Table 7.	21-15
21-5.4.6	Treatment Table 8.	21-17
21-5.4.7	Treatment Table 9.	21-18
21-5.5	Tending the Patient.	21-18
21-5.5.1	DMO or DMT Inside Tender.	21-18
21-5.5.2	Use of DMO.	21-18
21-5.5.3	Patient Positioning.	21-19
21-5.5.4	Equalizing During Descent.	21-19
21-5.5.5	Inside Tender Responsibilities.	21-19
21-5.5.6	Oxygen Breathing and Toxicity During Treatments.	21-19
21-5.5.7	Ancillary Care and Adjunctive Treatments.	21-20
21-5.5.8	Sleeping and Eating.	21-21
21-5.6	Recompression Chamber Life-Support Considerations.	21-21
21-5.6.1	Minimum Manning Requirements	21-22
21-5.6.2	Optimum Manning Requirements	21-22
21-5.6.3	Oxygen Control.	21-22
21-5.6.4	Carbon Dioxide Control.	21-23
21-5.6.5	Temperature Control.	21-23
21-5.6.6	Chamber Ventilation.	21-24
21-5.6.7	Access to Chamber Occupants.	21-25
21-5.6.8	Inside Tenders.	21-25
21-5.7	Loss of Oxygen During Treatment.	21-26
21-5.7.1	Compensation.	21-26
21-5.7.2	Switching to Air Treatment Table.	21-26
21-5.8	Use of High-Oxygen Mixes.	21-26
21-5.9	Treatment at Altitude - Tender Considerations	21-27
21-6	POST-TREATMENT CONSIDERATIONS	21-28
21-6.1	Post-Treatment Observation Period.	21-28
21-6.2	Post-Treatment Transfer.	21-28
21-6.3	Inside Tenders.	21-28
21-6.4	Flying After Treatments.	21-28
21-6.4.1	Emergency Air Evacuation.	21-28
21-6.4.2	Tender Surface Interval.	21-29
21-6.5	Treatment of Residual Symptoms.	21-29
21-6.5.1	Additional Recompression Treatments.	21-29
21-6.6	Returning to Diving after Treatment Table 5.	21-29

Chap/Para		Page
	21-6.6.1 Returning to Diving After Treatment Table 6.	21-29
	21-6.6.2 Returning to Diving After Treatment Table 4 or 7.	21-30
21-7	NON-STANDARD TREATMENTS	21-30
21-8	RECOMPRESSION TREATMENT ABORT PROCEDURES	21-30
21-8.1	Death During Treatment.	21-30
21-8.2	Oxygen Breathing Periods During Abort Procedure.	21-30
21-8.3	Impending Natural Disasters or Mechanical Failures.	21-30
21-9	EMERGENCY MEDICAL EQUIPMENT	21-31
21-9.1	Primary Emergency Kit.	21-31
21-9.2	Emergency Kits.	21-31
21-9.2.1	Primary Emergency Kit.	21-31
21-9.2.2	Secondary Emergency Kit.	21-31
21-9.2.3	Portable Monitor-Defibrillator.	21-32
21-9.3	Use of Emergency Kits.	21-32
21-9.3.1	Modification of Emergency Kits.	21-32
22	RECOMPRESSION CHAMBER OPERATION	
22-1	INTRODUCTION	22-1
22-1.1	Purpose.	22-1
22-1.2	Scope.	22-1
22-2	DESCRIPTION	22-1
22-2.1	Basic Requirements	22-1
22-2.1.1	Chamber Volume.	22-6
22-2.2	Modernized Chamber	22-6
22-2.3	Transportable Recompression Chamber System (TRCS)	22-6
22-2.4	Fly Away Recompression Chamber (FARCC).	22-6
22-2.5	Standard Features.	22-7
22-2.5.1	Labeling.	22-8
22-2.5.2	Inlet and Exhaust Ports.	22-9
22-2.5.3	Pressure Gauges.	22-9
22-2.5.4	Relief Valves.	22-9
22-2.5.5	Communications System.	22-9
22-2.5.6	Lighting Fixtures.	22-9
22-3	STATE OF READINESS	22-10
22-4	GAS SUPPLY	22-10
22-4.1	Capacity.	22-11
22-5	OPERATION	22-12

Chap/Para		Page
22-5.1	Predive Checklist	22-12
22-5.2	Safety Precautions	22-12
22-5.3	General Operating Procedures	22-15
22-5.3.1	Tender Change-Out.	22-15
22-5.3.2	Lock-In Operations.	22-15
22-5.3.3	Lock-Out Operations.	22-15
22-5.3.4	Gag Valves.	22-15
22-5.4	Ventilation	22-16
22-5.4.1	Chamber Ventilation Bill	22-16
22-5.4.2	Notes on Chamber Ventilation.	22-18
22-6	CHAMBER MAINTENANCE	22-19
22-6.1	Postdive Checklist	22-19
22-6.2	Scheduled Maintenance	22-19
22-6.2.1	Inspections.	22-19
22-6.2.2	Corrosion.	22-19
22-6.2.3	Painting Steel Chambers.	22-19
22-6.2.4	Recompression Chamber Paint Process Instruction.	22-21
22-6.2.5	Aluminum Chambers.	22-25
22-6.2.6	Fire Hazard Prevention.	22-25
22-7	DIVER CANDIDATE PRESSURE TEST	22-26
22-7.1	Candidate Requirements.	22-26
22-7.2	Inside Tender Requirements.	22-26
22-7.3	Procedure.	22-26
22-7.3.1	References.	22-26
5A	NEUROLOGICAL EXAMINATION	
5A-1	INTRODUCTION	5A-1
5A-2	INITIAL ASSESSMENT OF DIVING INJURIES	5A-1
5A-3	NEUROLOGICAL ASSESSMENT	5A-2
5A-3.1	Mental Status.	5A-5
5A-3.2	Coordination (Cerebellar/Inner Ear Function)	5A-5
5A-3.3	Cranial Nerves.	5A-6
5A-3.4	Motor.	5A-7
5A-3.4.1	Extremity Strength.	5A-8
5A-3.4.2	Muscle Size.	5A-8
5A-3.4.3	Muscle Tone.	5A-8
5A-3.4.4	Involuntary Movements.	5A-8
5A-3.5	Sensory Function.	5A-8
5A-3.5.1	Sensory Examination.	5A-10
5A-3.5.2	Sensations	5A-10

Chap/Para		Page
	5A-3.5.3 Instruments.	5A-10
	5A-3.5.4 Testing the Trunk.	5A-10
	5A-3.5.5 Testing Limbs.	5A-10
	5A-3.5.6 Testing the Hands.	5A-10
	5A-3.5.7 Marking Abnormalities.	5A-10
5A-3.6	Deep Tendon Reflexes	5A-10
5B	FIRST AID	
5B-1	INTRODUCTION	5B-1
5B-2	CARDIOPULMONARY RESUSCITATION	5B-1
5B-3	CONTROL OF MASSIVE BLEEDING.	5B-1
5B-3.1	External Arterial Hemorrhage.	5B-1
5B-3.2	Direct Pressure.	5B-1
5B-3.3	Pressure Points.	5B-1
	5B-3.3.1 Pressure Point Location on Face.	5B-2
	5B-3.3.2 Pressure Point Location for Shoulder or Upper Arm.	5B-2
	5B-3.3.3 Pressure Point Location for Middle Arm and Hand.	5B-2
	5B-3.3.4 Pressure Point Location for Thigh.	5B-2
	5B-3.3.5 Pressure Point Location for Foot.	5B-2
	5B-3.3.6 Pressure Point Location for Temple or Scalp.	5B-2
	5B-3.3.7 Pressure Point Location for Neck.	5B-2
	5B-3.3.8 Pressure Point Location for Lower Arm.	5B-2
	5B-3.3.9 Pressure Point Location of the Upper Thigh.	5B-2
	5B-3.3.10 Pressure Point Location Between Knee and Foot.	5B-4
	5B-3.3.11 Determining Correct Pressure Point.	5B-4
	5B-3.3.12 When to Use Pressure Points.	5B-4
5B-3.4	Tourniquet.	5B-4
	5B-3.4.1 How to Make a Tourniquet.	5B-4
	5B-3.4.2 Tightness of Tourniquet.	5B-5
	5B-3.4.3 After Bleeding is Under Control.	5B-5
	5B-3.4.4 Points to Remember.	5B-5
5B-3.5	External Venous Hemorrhage.	5B-6
5B-3.6	Internal Bleeding	5B-6
	5B-3.6.1 Treatment of Internal Bleeding.	5B-6
5B-4	SHOCK	5B-6
5B-4.1	Signs and Symptoms of Shock	5B-6
5B-4.2	Treatment	5B-7
5C	DANGEROUS MARINE ANIMALS	
5C-1	INTRODUCTION	5C-1
5C-1.1	Purpose.	5C-1

Chap/Para	Page
5C-1.2	Scope. 5C-1
5C-2	PREDATORY MARINE ANIMALS 5C-1
5C-2.1	Sharks 5C-1
5C-2.1.1	Shark Pre-Attack Behavior. 5C-1
5C-2.1.2	First Aid and Treatment. 5C-1
5C-2.2	Killer Whales 5C-3
5C-2.2.1	Prevention. 5C-4
5C-2.2.2	First Aid and Treatment. 5C-4
5C-2.3	Barracuda 5C-4
5C-2.3.1	Prevention. 5C-4
5C-2.3.2	First Aid and Treatment. 5C-4
5C-2.4	Moray Eels. 5C-4
5C-2.4.1	Prevention. 5C-5
5C-2.4.2	First Aid and Treatment. 5C-5
5C-2.5	Sea Lions. 5C-5
5C-2.5.1	Prevention. 5C-5
5C-2.5.2	First Aid and Treatment. 5C-5
5C-3	VENOMOUS MARINE ANIMALS 5C-6
5C-3.1	Venomous Fish (Excluding Stonefish, Zebrafish, Scorpionfish) 5C-6
5C-3.1.1	Prevention. 5C-6
5C-3.1.2	First Aid and Treatment. 5C-6
5C-3.2	Highly Toxic Fish (Stonefish, Zebra-fish, Scorpionfish). 5C-7
5C-3.2.1	Prevention. 5C-7
5C-3.2.2	First Aid and Treatment. 5C-7
5C-3.3	Stingrays 5C-9
5C-3.3.1	Prevention. 5C-9
5C-3.3.2	First Aid and Treatment. 5C-9
5C-3.4	Coelenterates 5C-9
5C-3.4.1	Prevention. 5C-10
5C-3.4.2	Avoidance of Tentacles. 5C-10
5C-3.4.3	Protection Against Jellyfish. 5C-10
5C-3.4.4	First Aid and Treatment. 5C-10
5C-3.4.5	Symptomatic Treatment. 5C-11
5C-3.4.6	Anaphylaxis. 5C-11
5C-3.4.7	Antivenin. 5C-11
5C-3.5	Coral 5C-11
5C-3.5.1	Prevention. 5C-11
5C-3.5.2	Protection Against Coral. 5C-11
5C-3.5.3	First Aid and Treatment. 5C-11
5C-3.6	Octopuses 5C-12
5C-3.6.1	Prevention. 5C-13
5C-3.6.2	First Aid and Treatment. 5C-13

Chap/Para		Page
5C-3.7	Segmented Worms (Annelida) (Examples: Bloodworm, Bristleworm)	5C-13
5C-3.7.1	Prevention.	5C-13
5C-3.7.2	First Aid and Treatment	5C-13
5C-3.8	Sea Urchins.	5C-14
5C-3.8.1	Prevention.	5C-14
5C-3.8.2	First Aid and Treatment	5C-14
5C-3.9	Cone Shells.	5C-15
5C-3.9.1	Prevention.	5C-15
5C-3.9.2	First Aid and Treatment	5C-15
5C-3.10	Sea Snakes.	5C-16
5C-3.10.1	Sea Snake Bite Effects.	5C-16
5C-3.10.2	Prevention.	5C-17
5C-3.10.3	First Aid and Treatment	5C-17
5C-3.11	Sponges	5C-18
5C-3.11.1	Prevention.	5C-18
5C-3.11.2	First Aid and Treatment	5C-18
5C-4	POISONOUS MARINE ANIMALS	5C-18
5C-4.1	Ciguatera Fish Poisoning	5C-18
5C-4.1.1	Prevention.	5C-19
5C-4.1.2	First Aid and Treatment	5C-19
5C-4.2	Scombroid Fish Poisoning	5C-19
5C-4.2.1	Prevention.	5C-20
5C-4.2.2	First Aid and Treatment	5C-20
5C-4.3	Puffer (Fugu) Fish Poisoning	5C-20
5C-4.3.1	Prevention.	5C-20
5C-4.3.2	First Aid and Treatment	5C-20
5C-4.4	Paralytic Shellfish Poisoning (PSP) (Red Tide).	5C-20
5C-4.4.1	Symptoms.	5C-21
5C-4.4.2	Prevention.	5C-21
5C-4.4.3	First Aid and Treatment	5C-21
5C-4.5	Bacterial and Viral Diseases from Shellfish.	5C-21
5C-4.5.1	Prevention.	5C-21
5C-4.5.2	First Aid and Treatment	5C-21
5C-4.6	Sea Cucumbers	5C-22
5C-4.6.1	Prevention.	5C-22
5C-4.6.2	First Aid and Treatment	5C-22
5C-4.7	Parasitic Infestation.	5C-22
5C-4.7.1	Prevention.	5C-22
5C-5	REFERENCES FOR ADDITIONAL INFORMATION	5C-22