

S0300-A6-MAN-030

0910-LP-252-3100

**U.S. NAVY
SHIP SALVAGE MANUAL
VOLUME 3
(FIREFIGHTING
AND DAMAGE CONTROL)**



DISTRIBUTION STATEMENT A: THIS DOCUMENT HAS BEEN APPROVED FOR PUBLIC RELEASE AND SALE; ITS DISTRIBUTION IS UNLIMITED.

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND

1 AUGUST 1991

FOREWORD

This manual is the third in a series of six related publications that comprise the *U.S. Navy Ship Salvage Manual*. Each volume in the family addresses a particular aspect of salvage. The family collectively replaces the three volumes of the *U.S. Navy Ship Salvage Manual* issued between 1968 and 1973.

The primary purpose of these volumes is to provide practical information of immediate use to Navy salvors in the field. These publications are not cook books; they are guidance. Salvors must use their imagination, intellect and experience to expand the basic information and apply it to a particular situation. A secondary purpose is to provide an educational vehicle for learning the technical and practical aspects of our business before the fact.

This volume, *Firefighting and Damage Control*, deals with an aspect of the Navy salvor's work that has not been formally addressed until now. Historically, providing services to battle-damaged ships has been one of the most important functions of the Navy salvor, greatly increasing the survivability of fleet units when the damaged ship's damage control organization becomes taxed or overwhelmed. This assistance inevitably involves firefighting because one of the principal effects of weapons strikes is to start large fires. Following World War II, Rear Admiral W. A. Sullivan, Chief of Navy Salvage and Supervisor of Salvage during the war, wrote:

“In most cases, vessels needing assistance as a result of damage inflicted by enemy action are afire or are a fire hazard. During a fire, it is most times impossible to engage in salvage operations other than ascertaining the damage and controlling flooding and stability, since salvage as well as firefighting personnel must engage in firefighting.”

Firefighting and damage control assistance are the most time-critical forms of salvage. The salvor assisting a stricken ship must understand the principles of his trade thoroughly and must think on his feet. This was aptly demonstrated during *Desert Storm* in the Persian Gulf when emergency support was provided following the USS PRINCETON (CG 59) and USS TRIPOLI (LPH 10) mine strikes. Rear Admiral Sullivan succinctly summarized the need for rapid information gathering and timely action: “...a conference cannot be held while the ship is sinking.”

R. P. FISKE

Director of Ocean Engineering

Supervisor of Salvage and Diving, USN

TABLE OF CONTENTS

Chapter/Paragraph	Page
Foreword	i
Table of Contents	iii
List of Illustrations	xiii
Standard Navy Syntax Summary	xvii
Safety Summary	xix
1 BATTLE DAMAGE	
1-1 INTRODUCTION	1-1
1-2 HISTORICAL PERSPECTIVE	1-2
1-3 WEAPONS EFFECTS	1-4
1-4 AFLOAT SALVAGE	1-6
1-4.1 Afloat Salvage Doctrine	1-8
1-4.1.1 Scenario	1-9
1-4.2 Platforms and Equipment	1-9
1-4.2.1 Fleet Salvage Ships	1-10
1-4.2.2 SARTs	1-11
1-4.2.3 Platforms of Opportunity	1-11
1-4.2.4 Commercial Salvage Ships	1-11
1-5 AFLOAT SALVAGE SERVICES	1-11
1-5.1 Offship Firefighting	1-11
1-5.1.1 External Firefighting Assistance	1-12
1-5.1.2 Internal Firefighting Assistance	1-12
1-5.2 Flooding Control and Dewatering	1-12
1-5.3 Ship Control	1-12
1-5.4 Restoration of Vital Services	1-12
1-6 SUMMARY	1-13
2 OFFSHIP BATTLE DAMAGE CONTROL ORGANIZATION	
2-1 INTRODUCTION	2-1
2-2 SALVAGE FORCE ORGANIZATION	2-1

Chapter/Paragraph	Page
2-2.1 Command and Control	2-1
2-2.2 Salvage Engineer	2-3
2-2.3 Coordination of Damage Control and Salvage Operations	2-3
2-2.4 Salvors' Interface with Combatants	2-4
2-2.5 Integration of Salvage Teams with Crews of Battle-damaged Ships . . .	2-4
2-2.6 Program of Ship Salvage Engineering (POSSE)	2-5
2-3 THE SALVAGE TEAM LEADER	2-6
2-3.1 Before Boarding the Casualty.	2-6
2-3.2 After Boarding the Casualty	2-6
2-3.3 Situation Reports.	2-7
2-4 SALVAGE ASSISTANCE RESPONSE TEAMS (SARTs)	2-8
2-4.1 SART Composition and Qualifications	2-9
2-4.1.1 General Qualifications for SART Members	2-10
2-4.1.2 Additional SART Qualifications	2-11
2-4.2 SART Operations	2-12
2-5 BATTLE DAMAGE ASSESSMENT	2-13
3 SALVAGE FIREFIGHTING PRINCIPLES	
3-1 INTRODUCTION	3-1
3-2 MARINE FIRES.	3-1
3-2.1 Chemistry of Fire	3-1
3-2.1.1 Fuels.	3-4
3-2.1.2 Heat	3-4
3-2.1.3 Oxygen.	3-6
3-2.2 Fire Behavior and Growth	3-6
3-2.3 Fire Extinguishment	3-8
3-2.4 Special Hazard Fires	3-8
3-2.4.1 Polar Solvent Fires.	3-8
3-2.4.2 Pressure Fires	3-9
3-2.4.3 Flowing Fires	3-9
3-2.4.4 Uncontained Fires	3-9

Chapter/Paragraph	Page
3-2.5 Characteristics and Hazards of Large and Unusual Fires	3-9
3-2.5.1 Size	3-9
3-2.5.2 Ship's Structure	3-9
3-2.5.3 Explosion	3-10
3-2.5.4 Aspiration	3-10
3-2.5.5 Boil Over and Spill Over	3-10
3-2.5.6 Class D Fires	3-14
3-2.5.7 Combustion and Hazardous Materials	3-14
3-2.5.8 Weapons and Explosives	3-16
3-2.5.9 Boiling Liquid Expanding Vapor Explosion	3-16
3-3 EXTINGUISHING AGENTS	3-17
3-3.1 Types of Agents	3-17
3-3.1.1 Starving Agents	3-17
3-3.1.2 Cooling Agents	3-17
3-3.1.3 Smothering Agents	3-18
3-3.1.4 Disrupting Agents	3-23
3-3.2 Water	3-24
3-3.2.1 Critical Flow Rate	3-24
3-3.2.2 Water Fog	3-25
3-3.2.3 Straight Streams	3-26
3-3.3 Agent Applicability and Compatibility	3-27
3-3.3.1 Applicability and Decision Making	3-27
3-3.3.2 Agent Compatibility and Precautions	3-29
3-3.4 Application Density	3-33
3-3.4.1 Water	3-33
3-3.4.2 Foam	3-34
3-4 FIREFIGHTING HYDRAULICS	3-39
3-4.1 Discharge Rate	3-40
3-4.2 Reach	3-41
3-4.3 Pressure Drop	3-42

Chapter/Paragraph	Page
3-4.3.1 Supply Pressure	3-43
3-4.3.2 Friction Loss	3-43
3-4.3.3 Friction Loss in Hose	3-44
3-4.3.4 Friction Loss in Appliances	3-45
3-4.3.5 Head Pressure.	3-46
3-4.5 Overcoming Friction Loss	3-46
3-5 VENTILATION	3-48
 4 FIREFIGHTING EQUIPMENT	
4-1 INTRODUCTION	4-1
4-2 PERSONAL EQUIPMENT	4-1
4-2.1 Protective Clothing	4-1
4-2.1.1 Proximity Firefighting Suits.	4-1
4-2.1.2 Standard Naval Firefighting Ensemble	4-1
4-2.1.3 Lightweight Firefighting Outfit	4-2
4-2.1.4 Alternative Clothing.	4-2
4-2.1.5 Salvage Firefighting Outfit	4-2
4-2.1.6 Standard Shipboard Battle Dress	4-2
4-2.2 Breathing Apparatus	4-5
4-2.2.1 Oxygen Breathing Apparatus.	4-5
4-2.2.2 Self-contained Breathing Apparatus	4-6
4-2.2.3 Oxygen Rebreathers.	4-7
4-2.3 Communications	4-7
4-3 FLEET FIREFIGHTING EQUIPMENT	4-7
4-3.1 Fire Pumps	4-8
4-3.2 Fire Stations, Hoses, and Accessories	4-8
4-3.3 Nozzles and Low-velocity Fog Applicators	4-9
4-3.3.1 The Vari-nozzle	4-9
4-3.3.2 Navy All-Purpose Nozzles and Applicators	4-9
4-3.4 Portable In-line Eductors and Water Motor Proportioners	4-11
4-3.4.1 The In-line Foam Eductor	4-11

Chapter/Paragraph	Page
4-3.4.2 The FP-180 Water Motor Foam Proportioner	4-13
4-3.5 Emergency Portable Fire Pumps.	4-13
4-3.6 Portable Dewatering Equipment.	4-17
4-3.7 Desmoking	4-19
4-3.8 Naval Firefighter's Thermal Imager	4-22
4-3.9 International Shore Connection	4-22
4-4 OFFSHIP FIREFIGHTING EQUIPMENT	4-24
4-4.1 Fixed Fire Pumps	4-24
4-4.2 Offship Delivery Capability	4-24
4-4.2.1 Monitors.	4-24
4-4.2.2 Offship Firefighting Manifolds	4-24
4-4.2.3 Portable Diesel Pumps	4-30
4-4.3 Hydraulic Power Units and Pumps.	4-30
4-4.3.1 Four-inch Hydraulic Submersible Pump	4-30
4-4.3.2 Six-inch Hydraulic Submersible Pump	4-31
4-4.4 Navy Portable Firefighting Pump Module	4-31
4-4.5 Hydraulic Submersible Firefighting Pumps	4-32
4-4.6 Commercial Portable Firefighting Pumps	4-33
4-4.6.1 Small Commercial Firefighting Pump Systems.	4-33
4-4.6.2 Large Commercial Firefighting Pump Units	4-34
4-4.7 Special Firefighting Tools and Adapters	4-36
4-4.8 Portable Foam Containers.	4-38
 5 FIREFIGHTING STRATEGIES FOR ASSISTING SHIPS	
5-1 INTRODUCTION	5-1
5-2 BATTLE DAMAGE FIREFIGHTING STRATEGIES	5-2
5-2.1 Basic Operational Phases	5-3
5-2.2 Strategies.	5-4
5-2.2.1 Containing Fires.	5-4
5-2.2.2 Controlling Fires	5-6
5-2.2.3 Extinguishing Fires	5-7

Chapter/Paragraph	Page
5-2.2.4	Flooding During Firefighting Operations 5-8
5-2.2.5	Cleanup 5-9
5-3	HANDLING AND CONTROL OF A CASUALTY'S HEADING DURING FIRE FIGHTING 5-9
5-3.1	Casualty with Complete or Partial Control of Engines and Steering . . 5-11
5-3.2	Casualty Drifting. 5-12
5-3.3	Ship Control Methods for Tugs Handling Large Casualties. 5-16
5-3.3.1	Taking the Casualty in Tow. 5-17
5-3.3.2	The Towing Rig 5-18
5-3.3.3	Getting the Tow Underway 5-19
5-3.3.4	Assisting Ship Tactics 5-21
5-4	FIREFIGHTING ON ANCHORED OR BEACHED SHIPS. 5-21
5-4.1	Firefighting on Anchored Casualties 5-23
5-4.2	Firefighting on Beached Ships 5-26
5-4.3	Deliberate Beaching of a Battle-damaged Ship 5-27
5-5	FIREFIGHTING ON MOORED SHIPS 5-28
6 SALVAGE SHIP FIREFIGHTING TACTICS	
6-1	INTRODUCTION 6-1
6-2	PREPARATION AND TESTING OF FIREFIGHTING EQUIPMENT. 6-2
6-2.1	The Pre-arrival Equipment Test 6-2
6-2.2	Strategy Formulation 6-4
6-3	APPROACH AND POSITIONING MANEUVERS 6-4
6-3.1	Drift and Relative Movement of the Casualty 6-5
6-3.2	Maneuvering Characteristics of the Salvage Ship 6-6
6-3.3	Optimum Firefighting Position Relative to Prevailing Wind. 6-7
6-3.4	Self-protection of Firefighting Ships 6-9
6-3.5	Speed and Maneuvers by the Casualty. 6-10
6-4	USE OF FIRE MONITORS ON SALVAGE SHIPS. 6-11
6-4.1	Use of Monitors 6-12
6-4.1.1	Indiscriminate Use 6-12

Chapter/Paragraph	Page
6-4.1.2	Effective Direction of Monitors. 6-13
6-5	FIREFIGHTING WITH COMMERCIAL VESSELS 6-14
6-5.1	Positioning of Portable Equipment. 6-14
6-5.2	Civilian Crew/Navy Interface. 6-15
6-5.3	FiFi Standards. 6-15
7	SALVAGE FIREFIGHTING TEAM TACTICS
7-1	INTRODUCTION 7-1
7-2	BOARDING THE CASUALTY 7-1
7-2.1	Initial Survey of the Casualty 7-1
7-2.2	Transportation of Personnel and Equipment 7-2
7-2.2.1	Use of Ships 7-2
7-2.2.2	Use of Boats. 7-2
7-2.2.3	Use of Work Boats as Pumping Tenders 7-3
7-2.2.4	Use of Helicopters 7-5
7-2.3	Transfer of Equipment 7-7
7-2.4	Integrating with Casualty Crew 7-7
7-3	PERSONNEL PROTECTION 7-7
7-3.1	Psychological Reactions to Disaster. 7-7
7-3.2	Physical Restrictions. 7-8
7-3.3	Breathing Apparatus Control 7-8
7-3.3.1	Changing Air Cylinders. 7-10
7-3.3.2	Recharging Air Cylinders 7-10
7-3.4	Attack Team Relief. 7-10
7-3.5	Rescue and MEDEVAC 7-11
7-4	FIREFIGHTING TEAM TACTICS. 7-15
7-4.1	Preliminary Actions 7-15
7-4.1.1	Staging for the Attack 7-16
7-4.1.2	Evaluating the Fire. 7-17
7-4.1.3	Setting Fire and Smoke Boundaries. 7-17
7-4.1.4	Manpower and Equipment Requirements 7-19

Chapter/Paragraph	Page
7-4.2 Attack and Control of Fires	7-20
7-4.2.1 Hand-held Hoseline Procedures	7-21
7-4.3 Application of Agents	7-23
7-4.3.1 Application of Water	7-23
7-4.3.2 Application of Foam	7-28
7-4.3.3 Application of Other Agents	7-28
7-4.4 Precautions and Tactics for Specific Locations	7-28
7-4.4.1 Accommodation Spaces	7-28
7-4.4.2 Cargo Holds and Containers	7-29
7-4.4.3 Fuel and Cargo Oil Tanks	7-31
7-4.4.4 Magazines and Weapons Hazards	7-31
7-4.4.5 Engine Rooms and Machinery Spaces	7-35

8 SECURING THE SHIP

8-1 INTRODUCTION	8-1
8-2 SURVEYING THE CASUALTY	8-2
8-2.1 Underwater Survey	8-3
8-2.2 Toxic and Explosive Gases	8-3
8-2.3 Battle Damage Assessment	8-3
8-3 ASSISTANCE WITH DAMAGE REPAIRS	8-4
8-3.1 Immediate Temporary Repairs	8-4
8-3.2 Water Damage Protection	8-6
8-3.3 Ancillary Services	8-7
8-4 REMOVAL OF CARGO, MUNITIONS, STORES, AND EQUIPMENT	8-7
8-5 PREPARING FOR TOW	8-8
8-6 COMPLETION OF SALVAGE SERVICES	8-10

APPENDICES

Appendix/Paragraph	Page
A DOCUMENTATION MATRIX	

Appendix/Paragraph	Page
B CONVERSION FACTORS APPLICABLE TO OFFSHIP FIREFIGHTING	
C SALVAGE FIREFIGHTING TEAM APPROACH CHECKOFF LIST	
D GENERAL OPERATING PROCEDURES FOR COMMERCIAL PORTABLE FIRE FIGHTING PUMPS	
D-1 INTRODUCTION	D-1
D-2 SYSTEM DESCRIPTION	D-1
D-2.1 Engine	D-1
D-2.2 Pump	D-2
D-2.3 Mounting	D-3
D-2.4 Base and Frame	D-3
D-2.5 Instrumentation	D-3
D-2.6 Monitor(s) and Discharge Manifold	D-3
D-2.7 Safety Features	D-3
D-2.8 Foam Injection	D-4
D-3 PUMP SETUP INSTRUCTIONS	D-4
D-3.1 Pre-operation Setup	D-4
D-3.2 Prestarting Procedures	D-5
D-3.3 Starting	D-6
D-3.4 Running Procedures	D-7
D-3.5 Stopping	D-7
D-3.6 Miscellaneous Operating Notes	D-8
D-3.6.1 Engine Will Not Start	D-8
D-3.6.2 Engine Stops While Idling	D-8
D-3.6.3 Engine Stops Running Under Load	D-8
D-3.6.4 Overspeed	D-9
D-3.6.5 The Pump Fails to Deliver after Filling and Starting	D-9
 Index	 Page
INDEX	Index-1

LIST OF ILLUSTRATIONS

Figure	Title	Page
1-1	Salvage Support for Ship Survivability Systems	1-7
1-2	Salvage Role in Survivability and Force Sustainability	1-8
2-1	Relationship of Salvage Control to Typical CWC Command Structure	2-2
3-1	The Fire Triangle	3-2
3-2	The Fire Tetrahedron	3-3
3-3	Effects of Conduction, Radiation and Convection	3-5
3-4	Temperature Effects on Steel	3-11
3-5	Temperature Effects on Aluminum (6061-T6).	3-12
3-6	Boil Over.	3-13
3-7	Production of Foam Concentrates.	3-21
3-8	Thermal Layering Disrupted by Water Fog	3-26
3-9	Slop Over	3-32
3-10A	Minimizing Friction Loss	3-47
3-10B	Minimizing Friction Loss	3-48
3-10C	Minimizing Friction Loss	3-49
4-1	Lightweight Firefighting Outfit	4-3
4-2	Salvage Firefighting Outfits	4-4
4-3	Typical Fire Station	4-8
4-4	Vari-Nozzle.	4-10
4-5	Navy All-Purpose Nozzles and Low-Velocity Water Fog Applicator Combinations	4-11
4-6	In-Line Foam Eductor.	4-12
4-7	Water Motor Foam Proportioner	4-13
4-8	P-250 Firefighting Arrangement.	4-14
4-9A	P-250 (MOD 1) Pump Unit	4-15
4-9B	P-250 (MOD 2) Pump Unit	4-16
4-10A	Eductors	4-18
4-10B	Eductor Operations	4-19

Figure	Title	Page
4-11	Red Devil Electric Blower	4-20
4-12	Air-Turbine-Driven Blower	4-21
4-13	Portable Blower Use	4-21
4-14	Naval Firefighter's Thermal Imager	4-22
4-15	International Shore Connection	4-23
4-16A	Salvage Ship Offship Firefighting Systems	4-25
4-16B	Salvage Ship Offship Firefighting Systems	4-26
4-17	Dual-Waterway Monitor and Fog-Master Nozzle	4-27
4-18	Single-Waterway Monitor	4-28
4-19	Air-Aspired Monitor	4-29
4-20	Offship Manifold and Portable Equipment.	4-30
4-21	Firefighting Connection for Salvage Pumps.	4-31
4-22	Navy Portable Firefighting Pump System	4-32
4-23	Small Commercial Salvage Firefighting Pump Module.	4-35
4-24	Large Portable Firefighting/Dewatering System	4-37
5-1	Design- and Salvor-Imposed Fire Zone Boundaries.	5-6
5-2	Unintentional Flooding and Loss of Stability.	5-10
5-3	Basic Evasive Maneuvers	5-13
5-4A	Typical Drift Aspects of High-Freeboard Ships in Wind Force Beaufort 9.	5-14
5-4B	Typical Drift Aspects of High-Freeboard Ships in Wind Force Beaufort 9.	5-14
5-5	Casualty Secured on Hip for Heading Control During Firefighting Operations	5-17
5-6	Moving Burning, Disabled Tanker to Optimum Heading	5-19
5-7	Emergency Towing Connections Suitable for Rigging on Disabled Burning Casualties	5-20
5-8	Optimum Configuration for Fighting Fires on Large Oil Carrier.	5-22
5-9	Change in Current Adversely Changes Heading of an Anchored Casualty	5-25
5-10	Effects of Major Alteration of Current on Fire Front Direction	5-26
6-1	Salvage Ship Positions When Assisting Drifting Casualty in Rough Weather or Otherwise Unable to Go Alongside	6-7
6-2	Salvage Ship Positioned to Windward for Firefighting Operations	6-8

Figure	Title	Page
6-3	Ineffectual Use of Monitors on a Major Internal Fire, Majority of Water Being Deflected from Fire by Superstructure that Encloses Fire	6-13
6-4	Effective Use of Monitors to Contain and Cool a Major “Open” Flaring Fire.	6-14
6-5	Common Arrangement of Portable Fire Pump Units on Chartered Oilfield Tug/Supply Ship	6-16
6-6	FiFi-1 Requirements for Firefighting Systems	6-17
6-7	FiFi-2 Requirements for Firefighting Systems	6-18
6-8	FiFi-3 Requirements for Firefighting Systems	6-19
7-1	Relationship of Work Boat to Casualty Vessels and Staging of Portable Pumps	7-4
7-2	Typical Deployment of Portable Firefighting Pump Unit on Standard 35-Foot Salvage Work Boat	7-4
7-3	Helicopter Transport of Portable Equipment	7-5
7-4	Example of Breathing Apparatus Control Board	7-9
7-5	Breathing Apparatus Cylinder Recharging Systems	7-11
7-6	Some Standard Rescue and Patient Transportation Devices	7-12
7-7	One Man Moving a Casualty	7-13
7-8	Two-Man Carries	7-14
7-9	Preparing a Victim for Helicopter Evacuation	7-15
7-10	Fire Ventilation	7-18
7-11	Analysis of the Fire Situation	7-19
7-12	Application of Hose Stream	7-22
7-13	Indirect Hose Attack Using Low-Velocity Applicator as a Sprinkler	7-23
7-14	Preferred Method-Enter Space and Attack Fire Directly	7-24
7-15	Fire Attack if High Temperature Denies Access	7-25
7-16A	Fire-Fighting From Above through a Vertical Trunk.	7-26
7-16B	Fire-Fighting From Above	7-27
7-17	Cargo Hold Layout of a Typical Break Bulk Ship	7-30
7-18	Attacking Small Oil Fire on Deck With Foam	7-33
7-19	Dry Magazine Sprinkling System.	7-34
7-20	Wet Magazine Sprinkling System	7-35

Figure	Title	Page
8-1	Emergency Compressed Air Fittings	8-6

STANDARD NAVY SYNTAX SUMMARY

Since this manual will form the technical basis of many subsequent instructions or directives, it utilizes the standard Navy syntax as pertains to permissive, advisory, and mandatory language. This is done to facilitate the use of the information provided herein as a reference for issuing Fleet Directives. The concept of word usage and intended meaning which has been adhered to in preparing this manual is as follows:

"Shall" has been used only when application of a procedure is mandatory.

"Should" has been used only when application of a procedure is recommended.

"May" and "need not" have been used only when application of a procedure is discretionary.

"Will" has been used only to indicate futurity; never to indicate any degree of requirement for application of a procedure.

The usage of other words has been checked against other standard nautical and naval terminology references.

SAFETY SUMMARY

This Safety Summary contains all specific WARNINGS and CAUTIONS appearing elsewhere in this manual. Should situations arise that are not covered by the general and specific safety precautions, the Commanding Officer or other authority will issue orders, as deemed necessary, to cover the situation.

GUIDELINES

Extensive guidelines for safety can be found in the OPNAV 5100 Series instruction manual, "Navy Safety Precautions." Personnel required to perform salvage operations must be thoroughly trained and equipped not only to perform routine duties but also to react appropriately to unusual or non-routine situations.

The officers and crew of vessels likely to be involved in salvage operations should continuously conduct safety indoctrination lectures and exercises aimed at reducing hazards and at reacting appropriately to unusual circumstances with professional understanding of their duties and the proper use of safety equipment.

PRECAUTIONS

The **WARNINGS** and **CAUTIONS** contained in this manual and listed below are referenced by page number. In addition, the following general precautions are offered as part of this Safety Summary:

- All personnel responsible for salvage should read and comprehend this manual.
- Observe all warnings, cautions, and notes listed in this manual.
- Follow operational procedures. Observe operating parameters of all equipment.

Definitions of warnings and cautions are as follows:

WARNING

A statement used to call particular attention to an action or procedural step which, if not strictly followed, could result in the injury or death of personnel.

CAUTION

A statement used to provoke notice, awareness, and attention from personnel regarding an action or procedural step which, if not followed, could result in possible injury or equipment malfunction.

The following warning and caution statements appear in this manual and are repeated here for emphasis:

WARNING

Water fog will non conduct electricity, but an inadvertent shift to solid stream causes severe electrocution hazards for the firefighter. (page 3-17)

WARNING

Inert gases will not support life and many of the vapors being displaced may be toxic. Ensure the safety of personnel and monitor the atmosphere at all times. (page 3-18)

WARNING

Corfam shoes and polyester clothing are not appropriate for any form of battle dress. When exposed to flame or high temperature, these materials melt and stick to the skin. (page 4-2)

WARNING

Fires involving nitrates, chlorates or other materials that produce oxygen when heated, should NEVER be battened down. Serious explosion may result. (page 7-29)

CAUTION

Hazardous materials are highly toxic and often difficult to detect. Familiarization with the effects and warning signs of exposure to these materials is a matter of education and training. The *U.S. Navy Ship Salvage Safety Manual*, S0-400-AA-SAF-010, provides guidance concerning hazardous materials. (page 3-14)

CAUTION

Navy salvage firefighters responsible for ordering or arranging resupply of foam concentrate overseas should realize that foam container sizes are figured in Imperial gallons or liters. An order for 55-gallon drums will confuse the foreign supplier who is used to an international system of “standard” drum sizes, where:

CAUTION

The operating times for air cylinders are based on the normal breathing rate of an average person. Air may be used more quickly due to exertion, extreme heat or the psychological effect of wearing a breathing apparatus. (page 7-10)

CAUTION

Ventilation of burning compartments may serve to intensify the fire by introducing oxygen. Venting should only be used during direct attacks. During indirect attacks, the area must be made as airtight as possible to keep oxygen out and the extinguishing agent confined. (page 7-18)

CAUTION

Check all hatch covers and vent dampers to ensure no agent leaks from the hold or air leaks in. Check for smoke or heat being pushed from openings and seal with sealant or tape. (page 7-30)

A

afloat salvage 1-1, 2-1
 doctrine 1-8
 historical perspective 1-2
 organization 2-1
 platforms and equipment 1-9
 purpose of 1-7
 services 1-11
 summary 1-13

agents
 applicability and compatibility 3-27
 application of 7-23
 application of other 7-28
 B 3-9
 CBR 2-13
 chemical 3-32
 compatibility and precautions 3-29
 cooling 3-17
 disrupting 3-23
 dry powders 3-23
 extinguishing 3-4, 3-8, 3-17, 3-20, 3-24, 4-1
 firefighting 1-12, 3-8, 5-8, C-2
 oxidizing 3-6, 7-31, 7-32
 secondary 3-23
 selecting 3-27
 smothering 3-23
 starving 3-17
 twinned 3-32
 wetting 3-20

air
 aspiration D-3
 banks 2-12, 4-6
 blowers 4-19
 bottles 4-6
 breathing apparatuses 2-12, 4-7
 breathing devices 4-6
 compressed 4-5, 4-7, 4-20
 compressors 2-12, 4-7, 7-10
 cylinders 7-10
 dewatering systems 8-5
 entrainment 3-25
 fittings 8-6
 foams 3-20
 friction 3-42
 locks D-8

LP 1-12, 1-13
 receivers 3-16
 storage cylinders 4-7
 vent D-8

anchored casualties 5-15, 5-23
 anchors
 beach gear 5-24, 5-28
 aspiration 3-10, 5-7, D-3
 attack team 4-2, 4-7, 5-4, 7-10

B

backdrafts 3-7, 3-8
 battle damage
 adapters 4-38
 assessment of 2-4, 2-13, 8-3
 assistance 1-1, 2-2
 control 6-4
 firefighting operations 4-36, 5-2, 5-9
 fires 5-2, 5-3, 5-6, 7-15
 introduction 1-1
 organization 7-1
 repairing 7-8
 response 2-7
 salvage operations 2-8

Battle Damage Assessment Teams (BDAT) 2-11, 2-13, 8-3

beach gear 1-10, 5-28
 beached casualties 7-5
 beaching 5-21, 5-24, 5-27 - 5-29
 berthing services 6-2, 8-1, 8-7, 8-10
 BLEVE (Boiling liquid expanding vapor explosion) 3-16, 5-21, C-1

blowers
 compressed air 4-20
 portable 4-19, 4-20
 Red Devil 4-19

boil over 3-10, 3-12, 3-13, 3-31, 5-21, 6-9, 7-31, C-1

booster suppression systems 7-31, 7-33

boundaries 2-4, 2-6, 3-9, 5-3 - 5-5, 5-7, 7-16, 7-17, 7-28
 confinement 5-28
 fire 5-1, 5-5, 5-7, 5-8, 5-10, 7-17
 fire and smoke 7-17
 fire control 5-3, 5-6
 fire zone 5-6
 primary 7-17

- secondary 7-17
 - smoke 7-16, 7-17
 - breathing apparatus 2-12, 3-15, 3-32, 3-33, 4-5, 4-7, 6-4, 7-8, 7-10, 7-11
 - quick release 2-12
 - buoyancy 3-1, 4-17, 5-1, 5-2, 5-4, 5-6, 5-8, 5-21, 5-27, 5-28, 6-20, 8-6, 8-8, 8-9
- C**
- carbon dioxide 3-3, 3-6, 3-8, 3-14, 3-18 - 3-20, 3-30, 4-5, 4-7
 - carbon monoxide 3-3, 3-6, 3-7, 3-14, 3-19
 - cargo 3-10, 3-38, 4-38, 5-16, 7-6, 8-1, 8-4, 8-7, 8-8
 - capacity 5-20
 - doors 5-28
 - holds 3-18, 3-20, 7-29
 - leakage 3-38
 - loadbinders D-4
 - manifests 7-31
 - net C-3
 - oil 5-7
 - oil tanks 3-30, 7-31
 - petroleum 5-6
 - POL 8-8
 - tank groups 3-38
 - tanks 3-19, 5-8, 7-31
 - casualties 1-1 - 1-3, 2-13, 4-24, 4-34, 5-16, 5-21, 6-11, 7-19, 8-7
 - anchored 5-23
 - battle-damaged 5-15, 6-1
 - beached 7-5
 - burning 5-11, 5-21
 - commercial 3-1
 - human 8-3
 - personnel 2-4, 5-1, 7-2, 7-16
 - shallow draft 6-11
 - cleanup 3-32, 5-3, 5-9
 - clothing 2-12, 3-27, 4-1, 4-32
 - alternative 4-2
 - firefighting 6-4
 - multi-layered 4-2
 - polyester 4-2
 - protective 2-13, 4-1, 7-20
 - welding 4-2
 - collision 1-1, 8-9
 - mats 1-10, 8-5
 - combustion 3-1, 3-3, 3-6 - 3-10, 3-14, 3-15, 3-17, 3-18, 3-23, 3-25, 3-30, 3-33, 3-49, 3-50, 4-19, 5-2, 5-3, 5-5, 5-7 - 5-9, 5-11, 5-12, 6-5, 6-7, 6-9, 7-21, 7-23, 7-31, 7-36
 - command and control 1-2, 2-1, 5-1, 5-24
 - communications 2-10, 2-12, 4-7, 7-1, 7-16, C-1
 - UHF 4-7
 - VHF 4-7
 - WIFCON 4-7
 - compartments 3-7, 3-10, 3-50, 4-5, 5-16, 7-21, 7-28, 7-36, 8-2, 8-3, 8-5, 8-9, 8-10
 - burning 7-17
 - dewatering 4-17, 4-30, 4-31
 - flooded 2-5
 - inaccessible 4-17
 - panelled 7-29
 - tool and equipment D-3
 - ventilate 3-25
 - watertight 5-4
 - weapons stowage 7-33
 - compressed air 4-20, 7-10, 8-5
 - conduction 3-5, 3-6, 5-5
 - convection 3-5, 3-6, 3-17, 5-5
 - conversion factors B-1, B-5 - B-7
 - cooling 2-7, 3-8, 3-10, 3-16 - 3-18, 3-23, 3-24, 3-26, 3-30, 3-31, 3-33, 4-2, 4-9, 4-24, 4-33, 5-4 - 5-9, 5-18, 5-21, 5-27, 6-3, 6-9, 6-11 - 6-13, 6-19, 6-20, 7-3, 7-8, 7-17, 7-23, 7-24, 7-28 - 7-31, 7-33, 7-36, C-2, D-1, D-3, D-5 - D-8
 - crisis management services 2-1
 - current 1-8, 2-5, 2-7, 2-10, 5-23 - 5-26, 6-9
- D**
- damage control 1-1, 1-12, 2-4, 2-5, 2-12, 7-7
 - equipment 2-1, 2-12, 8-8
 - firefighting 1-6
 - forces 2-1
 - operations 2-1 - 2-3, 2-13, 6-4, 8-9
 - organizations 1-1, 1-12, 1-13, 2-1, 2-4, 2-7, C-1
 - parties 1-10, 2-4, 2-5, 4-24
 - patches 1-12
 - personnel 1-13, 5-5
 - systems 1-6, 2-10
 - teams 1-8, 1-9, 1-13, 2-5

- training 7-7
- unit 2-4
- Damage Control Assistant (DCA) 2-7
- decontamination 2-13
- desmoking 4-19, 7-17, 7-20
- dewatering 1-11, 1-12, 2-6, 2-8, 4-17, 4-30, 5-3, 5-4, 5-9, 5-28, 7-2, 7-20, 8-1, 8-3, 8-5, 8-6, C-2
 - equipment 4-17, 7-2
 - pumps 1-10, 2-12
 - systems 4-37, 5-6, 5-8, 5-28, 8-5
- displacement 1-10, 2-8, 5-19, 5-20, 6-13, 8-2, D-1
- disrupters 3-8, 3-23
- documentation matrix A-1
- drafts 2-6, 2-8, 5-9, 6-5, 6-6, 8-2, C-2
- drifting 5-9, 5-12, 5-15, 5-17, 5-19, 6-1, 6-5 - 6-7, 6-8, 6-10, 6-14
 - casualty 5-13
- dry chemicals 3-8, 3-22, 3-23, 3-32, 7-28
- dry powders 3-23
- E**
- eductors 4-11, 4-13, 4-17, 4-18, 4-30
 - in-line foam 4-11
 - Peri-Jet 4-17
- effects 1-8
- electrocution 3-17
- engine rooms 3-24
- EOD 2-9, 2-11, 5-9, 7-19, 7-31
- equipment
 - firefighting 4-1, 4-7, 4-8, 4-22, 4-24, 4-38, 5-1, 5-5, 5-9, 5-27, 6-1 - 6-3, 6-8, 6-15, 7-5, 7-19, 7-28
 - personal 4-1
 - portable 1-2
- evasive maneuvers 5-11, 5-13
- explosions 3-1, 3-6, 3-9, 3-10, 3-24, 3-49, 7-7
 - backdraft 3-7, 3-50
 - smoke 3-7, 3-50
 - vapor/air 3-10
- explosive gases 3-10, 3-14, 3-15, 8-3
- explosives 3-6, 3-15, 3-16, 3-19, 3-24, 3-28, 6-2, 7-30, 7-32
- F**
- FiFi standards 6-15, 6-16
- fire
 - battle damage 1-1, 5-2, 6-19
 - boundaries 5-1, 5-5, 5-7, 5-10
 - chemistry 3-1
 - containment 5-1, 5-10, 6-9
 - draft tunnels 5-26
 - electrical 3-4
 - external 3-15, 4-2, 5-3, 5-16
 - flowing 3-9, 3-27, 3-31, 3-36
 - free-flowing 3-9
 - growth 3-6
 - internal 1-12, 3-15, 3-26, 5-2, 5-3, 6-19, 7-17
 - marine 3-1, 3-8, 3-9, 7-1, 7-7, 7-8, 7-15
 - monitors 1-3, 4-24, 5-3, 5-27, 6-1, 6-11, 6-15
 - portable pumps 1-4, 4-13, 4-38, 5-21, 6-4, 6-10, 6-14 - 6-16, 7-3
 - pumps 1-13, 2-6, 2-7, 2-12, 3-46, 4-8, 4-24, 4-31, 4-33, 5-27, 7-2, 7-5, D-1
 - sodium bicarbonate 3-20
 - special hazard 3-1, 7-15
 - spilling 3-38, 6-1
 - stations 3-43, 4-8
 - streams 3-25
 - tanker 3-1, 3-9, 5-6
 - tetrahedron 3-3, 3-7
 - three dimensional 3-36
 - triangle 3-2, 3-17, 3-23, 3-24
 - uncontained 3-9, 3-30, 3-36, 5-3, 6-9
 - ventilation 3-50
- fire plug 3-42, 3-43, 3-47
- firefighting
 - adapters 4-38
 - commercial vessels 6-14, 6-15
 - consumables 1-10, 1-13
 - defensive/self-preservation 1-1
 - equipment 7-5, 7-19, 7-28
 - hydraulics 3-39
 - oil field 1-4, 6-15, 6-19
 - position relative to prevailing wind 6-7
 - protective clothing 4-1
 - pumps 1-4, 1-12
 - salvage 5-1 - 5-5, 5-7, 5-8, 5-10, 5-16, 5-18, 5-21, 5-27, 5-29, 6-3, 6-5, 6-10, 6-14
 - ships 5-28, 5-29

- strategies 3-1, 5-1, 5-2, 5-4, 5-23
 - tools 4-8, 4-36
 - water 5-1, 5-8, 5-28
 - flashover 3-6, 3-7, 7-28
 - flooding 1-1, 1-2, 1-5 - 1-7, 1-11 - 1-13, 2-3, 2-6 - 2-8, 5-1, 5-4, 5-5, 5-8 - 5-10, 5-24, 5-28, 6-11 - 6-13, 6-19, 6-20, 7-20, 7-29, 7-31, 8-1 - 8-3, 8-5, 8-8, 8-10, C-2, D-5
 - control 1-11
 - dewatering 1-11
 - magazine 2-7, 5-5
 - unintentional 5-9, 5-10
 - flow rate 3-24, 3-25, 3-30, 3-34, 3-37, 3-39, 3-40, 3-42 - 3-46, B-3
 - foam
 - air 3-20
 - application density 3-24, 3-33
 - application of 7-22, 7-23, 7-28, 7-31, 7-33
 - application time 3-37, 3-39
 - Aqueous Film-Forming Foam (AFFF) 3-21
 - blankets 1-12, 6-2, 6-10
 - chemical 3-20
 - concentrates 1-13, 3-10, 3-20 - 3-22, 3-31, 3-37 - 3-39, 4-39
 - eductor systems 4-39
 - expansion rate 3-20
 - high-expansion 3-20
 - low-expansion 3-20, 3-21
 - mechanical 3-20
 - medium-expansion 3-20
 - protein 3-20, 3-22, 3-23, 3-31
 - storage tanks 4-38
 - fog 3-17, 3-18, 3-24, 3-26 - 3-30, 3-39 3-43, 4-9, 4-11, 4-20, 4-24, 4-27, 6-3, 6-9, 6-11, 7-21, 7-22, 7-24
 - high-velocity 3-24, 3-25, 3-27 - 3-29, 4-9, 4-24
 - low-velocity 3-24, 3-25, 4-9, 4-11
 - nozzles 3-40 - 3-43, 4-9, 4-11, 4-20, 4-31
 - streams 3-25, 3-26, 3-39, 3-40, 4-9, 6-9
 - free surface effects 5-9
 - freeboard 4-33, 5-1, 5-13, 5-14, 8-2
 - friction loss 3-42 - 3-49
 - in appliances 3-45
 - in hose 3-43, 3-44
 - overcoming 3-46
- G**
- gas pockets 3-10
 - gases 3-14, 3-15, 3-50, 5-7, 6-9, 7-17, 7-21 - 7-24, 8-3
 - explosive 3-16
 - life-threatening 3-49
 - toxic 3-9, 3-10, 3-14 - 3-16, 3-24, 4-6, 8-3
- H**
- halon 3-8, 3-14, 3-15, 3-22, 3-24, 3-28, 3-29, 3-33, 7-20, 7-29, 7-35, 7-36
 - handline 3-35, 3-37, 3-39, 3-40
 - head pressure 3-42, 3-46
 - heading 5-9, 5-10, 5-12, 5-18 - 5-20, 5-23
 - casualty's 5-2
 - control 5-13, 5-15 - 5-17
 - heat
 - balance 3-4, 3-26
 - transfer 3-5, 3-6, 3-17
 - zone 3-14
 - helicopters
 - characteristics of 7-6
 - overflight 7-1, 7-16
 - payload 7-6
 - transport of portable equipment 7-5
 - use of 7-5
 - hose
 - heavy 2-3
 - lines 1-3
 - stream 3-50
 - hoseline 6-9, 6-13, 7-8, 7-10, 7-20 - 7-22, 7-28, 7-29, 7-31, 7-33, 7-36
 - hand-held, procedures 7-21
 - hydraulic
 - firefighting 3-39
 - hydraulic power units 1-10, 2-12, 4-17, 4-30, 4-31, 7-3
 - hydraulic submersible pump
 - four-inch 4-30
 - six-inch 4-31
 - hydraulics 7-28
 - hydrocarbon-based fuels 3-14
 - hydrogen 3-6, 3-7, 3-14, 3-15, 3-24, 7-32
 - hydrogen chloride 3-14, 3-15, 3-24

I

ignition 3-4, 3-6, 3-7 - 3-10, 3-19, 3-25, 7-17,
7-23, 7-29, 7-31, 7-35, 7-36

inert gas 3-18 - 3-20

international shore connections 4-38

L

liquid inert gas 3-19

listing 6-6, A-1

logistics force 1-9, 1-10, 2-1

Lower Explosive Limit (LEL) 3-19

M

machinery spaces 3-38, 3-39, 3-50, 4-8

magazines 5-5

maneuvering

casualty 5-7, 5-9, 5-10 - 5-13, 5-15, 5-18, 5-
21, 6-1, 6-10

characteristics of the salvage ship 6-5, 6-6
evasive 5-11, 5-13

manifolds

firefighting 4-24

MEDEVAC 7-6, 7-11, 7-14, 7-15

mobile groups

logistics 1-9

salvage 1-6, 1-9

monitors

air-aspirated 4-24

dual-waterway 4-24, 4-27

effective use of 6-13, 6-14

fixed and portable 4-7, 4-24

installed 1-10, 6-10, 6-15

portable 1-10, 2-3

single-waterway 4-24, 4-28

munitions 1-1, 1-12, 3-1, 3-16, 3-38, 7-31, 8-1,
8-7, 8-8

N

Naval Firefighter's Thermal Imager (NFTI) 4-
22

nozzles 2-12, 3-20, 3-22, 3-39, 3-47

all-purpose 3-26, 3-40

fog 3-40, 3-42, 4-9

pressure 3-43

vari-nozzles 3-40, 3-41, 4-9

O

OBA 1-13, 4-5, 4-6, 6-9, 7-11, 7-19

off-loading 1-1, 8-7, 8-8, A-1, C-3

offship firefighting

equipment 6-1, 6-2

manifolds 3-43, 4-24, 4-30, 4-31, 6-2, 6-3

services 1-1, 2-3

offshore supply vessels 4-38, 6-14

oil carriers 5-16, 5-19, 6-9, 8-8

P

patching 1-10, 2-2, 2-12, 4-36, 5-3, 5-4, 5-9, 7-
19, 7-20, 8-1, 8-3, 8-5, C-2

personnel

protection 7-7, 7-10

transportation of 7-2

platforms of opportunity 1-4, 1-9, 1-11, 1-12,
2-4, 2-7, 2-8, 2-9, 4-31, 4-34, 4-38, 6-1,
6-9, 7-1

polar solvent fires 3-8, 3-22

portable equipment 1-4, 1-8, 1-11, 2-12, 3-16,
4-1, 4-7, 4-24, 4-30, 6-14, 6-15

portable inert gas systems 3-19

POSSE 2-3, 2-5

pre-arrival equipment test 6-2

propellant 1-3, 1-6, 3-9, 3-14, 3-16, 3-28, 5-8

protective clothing 2-13, 6-9

pumps

commercial 4-6, 4-31, 4-33, 4-34

dewatering 1-10

diesel driven 1-3

portable fire 1-3, 1-12, 4-31 - 4-33, 4-36, 4-
37

submersible 4-13, 4-17, 4-18, 4-30 - 4-32,
4-34, 7-3

R

radiation 3-4, 3-5, 3-17

radiative feedback 3-3, 3-6

radiological hazards 3-15

refloating 5-27, 5-28

repair

battle damage 8-4

mobile 1-2, 2-2

ship 1-2

rescue

tugs 6-1

Rescue and Assistance (R&A) team 7-1

rigging 1-10, 2-11, 5-7, 5-18, 5-20, 6-3, 6-4, 6-
10, 8-2, 8-9, 8-10

rubber-lined hose flow rates 3-43, 3-45

S

salvage engineer 2-3, 2-6, A-1
 salvage ships
 capabilities 1-8, 1-10
 commercial 1-3, 1-11
 salvage teams 1-9, 1-10, 1-12, 1-13, 2-4, 2-13,
 7-2, 7-7
 sealing 5-9, 8-3, 8-5, D-5
 self-contained breathing apparatus 4-2, 4-6
 ship control 1-11, 1-12, 5-1, 5-12, 5-15, 5-16,
 5-21, 5-27, 6-14, 8-9
 Ship Salvage Engineering, program of (POS-
 SE) 2-3, 2-5
 ships
 beached 5-21, 5-26, 5-27
 commercial 1-3, 1-4
 of opportunity 2-3, 2-4, 2-6, 2-8, 2-9
 threats to surface ships 1-4
 shoring 1-10, 1-12
 SITREP 2-4, 2-7, 2-8, 7-1, 7-7
 slop over 3-31, 3-32
 smoke
 inhalation 3-15
 smoldering combustion 3-4, 3-7
 smothering agents 3-18
 spill over 3-10, 3-12, 3-13, 7-31
 sprinklers 7-22, 7-31, 7-36
 stability
 afloat 1-2
 assessments 2-3
 loss of 5-8 - 5-10, 5-27
 strength 3-10, 5-16, 5-23, 7-32, 8-2, 8-8, 8-10
 assessments 2-3
 degradation 2-5
 structural
 envelope 3-9
 failure 3-9
 integrity 2-6, 2-7
 patches, installation of 2-3
 Submersible 4-31
 suction lift 1-3, 4-31 - 4-34, 7-3, D-2, D-4
 superstructure 5-5, 5-7, 6-6, 6-12, 6-13
 surfactants 3-20, 3-21
 survivability systems 1-7

T

temperature

 auto-ignition 3-7
 effects on aluminum 3-12
 effects on steel 3-10
 thermal imager 4-22
 towing
 alongside 5-15, 5-16
 connections 5-19, 5-20, 8-9
 emergency 5-18, 8-9
 pendants 5-18, 8-9
 rig 5-15, 5-18
 tactics 5-1, 5-2, 5-17
 toxic gases 3-16, 4-6
 training
 damage control team 2-5
 diving 2-9
 firefighting basic 2-11
 firefighting team 2-11
 pre-deployment 2-10
 underwater damage assessment/repair 2-11
 trim 1-13, 2-6, 2-8, 4-31, 5-1, 5-5, 5-6, 5-12, 6-
 5, 6-6, 7-7, 7-16, 8-8 - 8-10, C-2
 tugs
 commercial salvage 1-9
 fleet tugs (ATF) 1-2

U

U.S. Navy Ship Salvage Manual 1-2, 1-4, 3-20,
 4-31, 5-9, 8-2, 8-5, 8-8, A-1, B-1
 U.S. Navy Towing Manual 5-15, 5-18, 6-5, 8-
 9, A-1
 underwater survey 8-3

V

vari-nozzle 3-18, 3-22, 3-31, 3-40, 3-41, 4-9, 4-
 10
 ventilation 1-12, 3-7, 3-10, 3-30, 3-48 - 3-50, 4-
 19, 5-5, 5-23, 7-17, 7-28, 7-29
 mechanical 3-50
 systems 1-12, 5-5

VERTREP 2-6, 5-19

vital services, restoration of 1-13

W

water
 application density rates (ADR) 3-35
 application of 7-23
 curtains 3-17, 6-9
 damage protection 8-6, 8-7

- high-volume 5-5
- primary cooling agent 3-17
- slippery 3-17, 3-46
- thick 3-17
- wall 5-5
- wet 3-17
- water fog 3-25, 3-26, 3-28, 3-30, 4-9
- weapons
 - damage 1-4, 1-5
 - effects 1-4, 1-5, 1-8, 5-2
 - hazards 7-31
 - mines 1-4
 - torpedoes 1-4
- weather conditions 5-9, 5-10, 5-15, 6-2, 6-8, 7-7
- weight
 - changes, effects of 2-5
 - distribution of 2-3
- wind 1-12, 2-6, 3-9, 3-10, 3-41, 3-50, 5-2, 5-5, 5-7, 5-9 - 5-12, 5-14 - 5-18, 5-21 - 5-24, 6-4 - 6-10, 6-15, C-3
- work boats
 - use of 7-2, 7-3

Y

- yaw 5-23