

Third Edition

BASIC DECOMPRESSION

Theory and Application

BRUCE R. WIENKE



DIVERSification
SERIES

A small silhouette of a diver is positioned below the word "SERIES".

Best Publishing Company

Published - 1991
Second Edition - 2003
Third Edition - 2008



A
S
2008



No responsibility is assumed by the Publisher or Editor for any injury and/or damage to persons or property as a matter of product liability, negligence or otherwise, or from any use or operation of any methods, product, instructions or ideas contained in the material herein. No suggested test or procedure should be carried out unless, in the reader's judgement, its risk is justified. Because of rapid advances in the medical sciences, we recommend that the independent verifications of diagnoses and drug dosages are the responsibilities of the authors.

All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the publisher.

Copyright © 2008 by Best Publishing Company

Printed and bound in the United States of America

International Standard Book Number: 978-1-930536-45-6

Library of Congress catalog card number: 2007943429

Published by:
Best Publishing Company
Post Office Box 30100
Flagstaff, AZ 86003-0100, USA

www.bestpub.com

TABLE OF CONTENTS

ABSTRACT	vii	
PROLOGUE .....	.xi	
CONVENTIONS AND UNITS .....	.xiii	
DIVING HISTORY .....	.xxi	
ACKNOWLEDGMENTS .....	.xxvii	
Chapter 1	GAS, FLUID, AND PHASE KINETICS	1
	<i>Ideal Gases</i>	1
	<i>Real Gases</i>	3
	<i>Collisional Phenomena</i>	5
	<i>State Variables and Energy Balance</i>	7
	<i>High Pressure Equipment and Flows</i>	14
	<i>Steady Flow</i>	17
	<i>Dissolved Phase Transfer</i>	19
	<i>Perfusion Controlled Transport</i>	20
	<i>Diffusion Controlled Transport</i>	21
	<i>Free Phase Transfer</i>	22
Chapter 2	CRITICAL TENSIONS AND PHASE VOLUMES	35
	<i>Critical Tensions and Decompression</i>	35
	<i>Controlling Tissues</i>	38
	<i>Time Remaining</i>	39
	<i>Saturation Curve and Separated Phase</i>	40
	<i>Critical Phase Volumes</i>	42
	<i>Ascent Staging</i>	46
Chapter 3	ALTITUDE SIMILARITY AND PROCEDURES	57
	<i>Reduced Atmospheric Pressure</i>	57
	<i>Critical Extrapolations</i>	58
	<i>Altitude Procedures</i>	58
	<i>Altitude Delay Time</i>	62
	<i>Equivalent Decompression Ratios</i>	64
	<i>Extended Haldane Staging</i>	65
	<i>Equipment and Consumption Rate Effects</i>	67
Chapter 4	MIXED GASES AND DECOMPRESSION	85
	<i>Mixtures and Biological Reactivities</i>	85
	<i>Comparative Properties</i>	87
	<i>Nitrox</i>	90

	<i>Heliox</i> .....	.91
	<i>Trimix</i> .....	.92
	<i>Hydrox</i> .....	.92
	<i>Haldane Decompression Procedures</i> .....	.93
	<i>Equivalent Air Depth</i> .....	.94
	<i>Equivalent Mixture Depth</i> .....	.95
	<i>Best Diving Mixture</i> .....	.95
	<i>Gas Mixing</i> .....	.96
	<i>Oxygen Rebreathing</i> .....	.98
	<i>Oxygen Exposures and Toxicity</i> .....	.100
	<i>Isobaric Countertransport</i> .....	.105
Chapter 5	DECOMPRESSION TABLES, METERS, AND MODELS .....	.117
	<i>Protocols</i> .....	.117
	<i>Tables</i> .....	.117
	<i>Meters</i> .....	.120
	<i>Model History</i> .....	.122
	<i>Bulk Diffusion Model</i> .....	.123
	<i>Multitissue Model</i> .....	.124
	<i>Thermodynamic Model</i> .....	.127
	<i>Varying Permeability Model</i> .....	.127
	<i>Reduced Gradient Bubble Model</i> .....	.130
	<i>Tissue Bubble Diffusion Model</i> .....	.131
Chapter 6	COMPARATIVE PROFILES AND OPERATIONAL DIVING .....	.141
	<i>Haldane Profiles</i> .....	.141
	<i>Empirical Practices</i> .....	.149
	<i>Phase versus Haldane Profiles</i> .....	.152
	<i>Validation and Testing</i> .....	.167
	<i>Deep Stops and Helium</i> .....	.168
	<i>Helium Strategies</i> .....	.176
Chapter 7	DECOMPRESSION RISKS AND STATISTICS ..	.185
	<i>Systematics and Issues</i> .....	.185
	<i>Binomial Distribution</i> .....	.186
	<i>Normal Distribution</i> .....	.188
	<i>Poisson Distribution</i> .....	.189
	<i>Probabilistic Decompression</i> .....	.190
	<i>Maximum Likelihood</i> .....	.192
	<i>Saturation Bends Probability</i> .....	.195
	<i>Risk Tables</i> .....	.196

Chapter 8	APPLICATION, COMPUTING, AND DECOMPRESSION ALGORITHMS .....	.203
	<i>Computing Advances</i> .....	.203
	<i>Supercomputers</i> .....	.203
	<i>Networks</i> .....	.206
	<i>Storage</i> .....	.207
	<i>Grand Challenge Applications</i> .....	.209
	<i>Multilevel Dive Profile Analysis</i> .....	.216
	<i>Computational Models and Algorithms</i> .....	.218
Chapter 9	DIVING MALADIES AND DRUGS .....	.249
	<i>Maladies</i> .....	.249
	<i>Bends</i> .....	.249
	<i>High Pressure Nervous Syndrome</i> .....	.250
	<i>Inert Gas Narcosis</i> .....	.251
	<i>Hyperoxia and Hypoxia</i> .....	.252
	<i>Hypercapnia and Hypocapnia</i> .....	.253
	<i>Barotrauma</i> .....	.255
	<i>Altitude Sickness</i> .....	.257
	<i>Pulmonary Edema</i> .....	.257
	<i>Hypothermia and Hyperthermia</i> .....	.258
	<i>Dysbaric Osteonecrosis</i> .....	.258
	<i>Drugs</i> .....	.259
Chapter 10	BUBBLES AND BIOSYSTEMS .....	.265
	<i>Doppler Effect</i> .....	.265
	<i>Moving Bubbles</i> .....	.266
	<i>Operational Protocols</i> .....	.267
	<i>Pulmonary and Circulatory Networks</i> .....	.270
	<i>Inherent Unsaturation</i> .....	.273
	<i>Surface Tension</i> .....	.275
	<i>Adsorption</i> .....	.276
	<i>Surfactants</i> .....	.276
	<i>Micronuclei</i> .....	.278
	<i>Free Phases</i> .....	.281
	<i>Nucleation</i> .....	.281
	<i>Cavitation</i> .....	.283
	<i>Bubble and Seed Pressure Response</i> .....	.286
	EPILOGUE .....	.297
	BIBLIOGRAPHY .....	.299
	INDEX .....	.311



Bruce Wienke is an Instructor Trainer/ Technical Instructor with the National Association of Underwater Instructors (NAUI), has served on the Board of Directors (Vice Chairman for Technical Diving, Technical and Decompression Review Board Member), is a Master Instructor with the Professional Association of Diving Instructors (PADI), an Institute Director with the YMCA, and is an Instructor Trainer/ Technical Instructor with Scuba Diving International/Technical Diving International (SDI/TDI).

This monograph updates and extends the first edition of *Basic Decompression Theory and Application*. A major focus is modern, dual phase, diver staging strategies, in theory, application, and testing. Decompression theory is coupled to phase mechanisms in a ten-chapter series. Topics include energy and thermodynamics, pressure and density, flow mechanics, gas kinetics, free and dissolved phase transfer, equation of state, bubbles and surfactants, nucleation and cavitation, mixed gases, risk and statistics, computing models, tables, meters, and decompression software. Extensive references are included, along with sample problems and solutions.

ISBN-13 978-1-930536-45-6



9 781930 536456



Visit our website for
additional publications:
www.bestpub.com