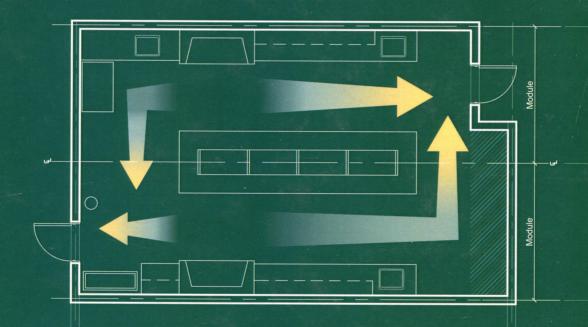
Laboratory Design

Health, Safety, and Environmental Considerations



Louis J. DiBerardinis

Janet S. Baum • Melvin W. First

Gari T. Gatwood • Anand K. Seth

GUIDELINES FOR LABORATORY DESIGN

Health, Safety, and Environmental Considerations

Fourth Edition

LOUIS J. DIBERARDINIS JANET S. BAUM MELVIN W. FIRST GARI T. GATWOOD ANAND K. SETH Copyright © 2013 by John Wiley & Sons, Inc. All rights reserved

Published by John Wiley & Sons, Inc., Hoboken, New Jersey Published simultaneously in Canada

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4470, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at http://www.wiley.com/go/permissions.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information on our other products and services or for technical support, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic formats. For more information about Wiley products, visit our web site at www.wiley.com.

Library of Congress Cataloging-in-Publication Data:

DiBerardinis, Louis J., 1947-

Guidelines for laboratory design: health, safety, and environmental considerations / Louis J. DiBerardinis, Janet S. Baum, Melvin W. First, Gari T. Gatwood, Anand K. Seth. – Fourth edition.

pages cm

Includes bibliographical references and index.

ISBN 978-0-470-50552-6 (hardback)

1. Laboratories-Design and construction. 2. Laboratories-Safety measures. I. Title.

TH4652.G85 2013

727'.5-dc23

2012048262

Printed in the United States of America

 $10 \ \ 9 \ \ 8 \ \ 7 \ \ 6 \ \ 5 \ \ 4 \ \ 3 \ \ 2 \ \ 1$

CONTENTS

FO	REW	ORD	XV
PR	EFAC	CE CONTRACTOR OF THE CONTRACTO	xvii
AC	KNO	WLEDGMENTS	xix
AB	OUT	THE AUTHORS	xxi
AB	BRE	VIATIONS	xxiii
UN	IITS		XXV
OR	GAN	IZATIONS REFERENCED	xxvii
INTRODUCTION		xxix	
	Bool	to Use This Book, xxx c Organization, xxxi putational Fluid Dynamics, xxxiii	
PA	RT IA	COMMON ELEMENTS OF LABORATORY DESIGN	1
1	Build	ding Considerations	3
	1.1 1.2 1.3 1.4 1.5	Guiding Concepts, 3 Building Layout, 3 Guiding Principles for Building Heating, Ventilating, and Air-Conditioning Systems, 44 Guiding Concepts for Laboratory Building Loss Prevention, Industrial Hygiene, and Personal Safety, 51 Miscellaneous Services, 56	
2	Labo	oratory Considerations	65
PA	RT IE	COMMON ELEMENTS OF RENOVATIONS	109
3	Reno	ovations: Building Considerations	123
	3.1 3.2	Guiding Concepts, 123 Building Layout, 125	

	CONTRACTOR
VIII	CONTENTS

	3.3 3.4	Heating, Ventilating, and Air-Conditioning Systems, 129 Loss Prevention, Industrial Hygiene, and Personal Safety, 133	
	3.5	Miscellaneous Services, 134	
4	Reno	ovations: Laboratory Considerations	136
	4.1	Guiding Concepts, 136	
	4.2	Laboratory Layout, 137	
	4.3	Heating, Ventilating, and Air-Conditioning Systems, 138	
	4.4	Loss Prevention, Industrial Hygiene, and Personal Safety, 138	
PA	RT II	DESIGN GUIDELINES FOR A NUMBER OF COMMONLY USED LABORATORIES	141
5	Gene	eral or Analytical Chemistry Laboratory	143
	5.1	Description, 143	
	5.2	Laboratory Layout, 144	
	5.3	Heating, Ventilating, and Air-Conditioning, 146	
	5.4	Loss Prevention, Industrial Hygiene, and Personal Safety, 149	
	5.5	Special Requirements, 149	
6	High	-Toxicity Laboratory	150
	6.1	Description, 150	
	6.2	Laboratory Layout, 151	
	6.3	Heating, Ventilating, and Air-Conditioning, 153	
	6.4 6.5	Loss Prevention, Industrial Hygiene, and Personal Safety, 154 Special Requirements, 155	
7	Nano	technology Laboratories	156
	7.1	Description, 156	
	7.2	Laboratory Layout, 156	
	7.3	Heating, Ventilating, and Air-Conditioning, 157	
	7.4	Loss Prevention, Industrial Hygiene, and Personal Safety, 158	
8	Engi	neering Laboratories	160
	8.1	Description, 160	
	8.2	Engineering Disciplines and Some of Their Most Common	
		Laboratory Types, 160	
	8.3	Wind Tunnel Laboratory, 161	
	8.4	Jet and Rocket Propulsion Laboratory, 162	
	8.5	Hydraulics Laboratory, 164 Motorial Applysis and Testing Laboratory, 165	
	8.6 8.7	Material Analysis and Testing Laboratory, 165 Electrical Circuits, Motors, and Generators Laboratory, 165	
	8.8	Foundry Laboratory, 167	
	8.9	Internal Combustion and Gas Turbine Engine Laboratory, 169	
9	Pilot	Plant: Chemical, Engineering, and Biological	173
	9.1	Description, 173	
	9.2	Pilot Plant Layout, 174	
	9.3	Heating, Ventilating, and Air-Conditioning, 174	

	9.4 9.5	Loss Prevention, Industrial Hygiene, and Personal Safety, 175 Special Requirements, 175	
10	Physics Laboratory		
	10.1 10.2 10.3 10.4 10.5	Description, 177 Laboratory Layout, 178 Heating, Ventilating, and Air-Conditioning, 179 Loss Prevention, Industrial Hygiene, and Personal Safety, 179 Special Requirements, 181	
11	Cont	rolled Environment Room: Hot or Cold	182
	11.1 11.2 11.3 11.4 11.5	Description, 182 Laboratory Layout, 183 Heating, Ventilating, and Air-Conditioning, 183 Loss Prevention, 185 Special Requirements, 185	
12	High	-Pressure Laboratory	187
	12.1 12.2 12.3 12.4 12.5	Description, 187 Laboratory Layout, 188 Heating, Ventilating, and Air-Conditioning, 188 Loss Prevention, Industrial Hygiene, and Personal Safety, 189 Special Requirements, 189	
13	Radia	ation Laboratory	190
	13.1 13.2 13.3 13.4 13.5	Description, 190 Laboratory Layout, 191 Heating, Ventilating, and Air-Conditioning, 194 Loss Prevention, Industrial Hygiene, and Personal Safety, 195 Special Considerations, 195	
14	Biosa	ifety Laboratory	196
	14.1 14.2 14.3 14.4 14.5	Description, 196 Laboratory Layout, 202 Heating, Ventilating, and Air-Conditioning, 212 Loss Prevention, Industrial Hygiene, and Personal Safety, 213 Special Requirements, 213	
15	Clinic	cal Laboratories	216
	15.1 15.2 15.3 15.4	Description, 216 Laboratory Layout, 218 Heating, Ventilating, and Air-Conditioning, 222 Loss Prevention, Industrial Hygiene, and Personal Safety, 223	
16	Teach	ning Laboratory	227
	16.1 16.2 16.3 16.4	Description, 227 Laboratory Layout, 228 Heating, Ventilating, and Air-Conditioning, 234 Loss Prevention, Industrial Hygiene, and Personal Safety, 235	

17	Gross Anatomy Laboratory	238	
	 17.1 Description, 238 17.2 Laboratory Layout, 239 17.3 Heating, Ventilating, and Air-Conditioning, 243 17.4 Loss Prevention, Industrial Hygiene, and Personal Safety, 17.5 Security, 245 	244	
18	Pathology Laboratory	246	
	 18.1 Description, 246 18.2 Laboratory Layout, 249 18.3 Heating, Ventilating, and Air-Conditioning, 251 18.4 Loss Prevention, Industrial Hygiene, and Personal Safety, 18.5 Special Requirements, 252 	251	
19	Autopsy Laboratory	253	
	 19.1 Description, 253 19.2 Laboratory Layout, 255 19.3 Heating, Ventilating, and Air-Conditioning, 260 19.4 Loss Prevention, Industrial Hygiene, and Personal Safety, 	261	
20	Morgue Facility	262	
	 20.1 Description, 262 20.2 Laboratory Layout, 265 20.3 Heating, Ventilating, and Air-Conditioning, 269 20.4 Loss Prevention, Industrial Hygiene, and Personal Safety, 	269	
21	Open or Team Research Laboratory		
	 21.1 Description, 271 21.2 Laboratory Layout, 272 21.3 Heating, Ventilating, and Air-Conditioning, 275 21.4 Loss Prevention, Industrial Hygiene, and Personal Safety, 21.5 Special Considerations, 276 	275	
22	Animal Research Laboratory		
	 Description, 277 Laboratory Layout, 279 Heating, Ventilating, and Air-Conditioning, 292 Loss Prevention, Industrial Hygiene, and Personal Safety, Special Requirements, 297 	296	
23	Microelectronics and Cleanroom Laboratories		
	 Description, 299 Laboratory Layout, 303 Heating, Ventilating, and Air Conditioning, 307 Loss Prevention, Industrial Hygiene, and Personnel Safety Special Requirements, 312 Renovations, 314 	v, 310	
24	Printmaking Studio		
	24.1 Description, 31524.2 Print Studio Layout, 317		

	24.3 24.4	Heating, Ventilating, and Air-Conditioning, 318 Loss Prevention, Industrial Hygiene, and Personal Safety, 321	
PA	RT III	LABORATORY SUPPORT SERVICES	325
25	Imag	ing and Photographic Facilities	327
		Introduction, 327 Photographic And Imaging Facility Layouts, 331 Heating, Ventilating, and Air-Conditioning, 334 Loss Prevention, Industrial Hygiene, and Personal Safety, 336 Special Requirements, 337	
26	Supp	ort Shops	339
	26.3	Description, 339 Layout, 340 Heating, Ventilating, and Air-Conditioning, 344 Loss Prevention, Industrial Hygiene, and Personal Safety, 346 Special Requirements, 346	
27		rdous Chemical, Radioactive, and Biological e-Handling Rooms	348
		Guiding Concepts, 348 Layout, 351 Heating, Ventilating, and Air-Conditioning, 356 Loss Prevention, Industrial Hygiene, and Personal Safety, 358 Special Requirements, 358	
28	Labo	ratory Storerooms	360
	28.1 28.2 28.3 28.4 28.5	Description, 360 Layout, 363 Heating, Ventilating, and Air-Conditioning, 366 Loss Prevention, Industrial Hygiene, and Personal Safety, 367 Special Requirements, 368	
PA	RT IV	HVAC SYSTEMS	369
29	HVAC Systems		
	29.1 29.2 29.3 29.4 29.5 29.6 29.7	Description, 371 Air-Conditioning Systems, 371 HVAC System Design and Description, 376 System Descriptions and Strategies, 377 Humidification and Dehumidification, 386 Space Pressure Control, 389 Automatic Control System, 391	
30	Fans		392
	30.1 30.2	Fan Terminology, 392 Exhaust Fan Specifications, 393	

xii	CONTENTS		
	30.3	Atmospheric Dispersion, 394	
		Fan Laws, 394	
		Fan Selection, 395	
	30.6	Fan Performance, 396	
31	Air C	leaning	397
	31.1	Introduction, 397	
	31.2	Air-Cleaning Equipment for Laboratories, 398	
32		ratory Hoods and Other Exhaust Air Contaminant-Capture	40.4
	Facilit	ties and Equipment	404
	32.1	Introduction, 404	
	32.2	Conventional Bypass Chemical Fume Hoods, 405	
	32.3	Auxiliary Air Chemical Fume Hoods, 409	
	32.4 32.5	Perchloric Acid Fume Hoods, 411 Hoods for Work With Radioactive Materials, 411	
	32.5	Variable Air-Volume Hoods, 411	
	32.7	High-Performance Hoods, 412	
		Gloveboxes, 412	
	32.9	Biological Safety Cabinets, 413	
		Capture (Exterior) Hoods, 416	
		Ductless Hoods, 416	
	32.12	Performance Tests, 420	
33	Exhaust Air Ducts and Accessories		422
	33.1	Introduction, 422	
		Exhust Duct Considerations, 423	
		Exhust System Classification, 424	
	33.4	Duct Accessories, 424	
34	Variable-Air-Volume Systems		
	34.1	Introduction, 426	
	34.2	VAV Hoods, 427	
	34.3	Good Design Practices for Vav Systems, 428	
	34.4	Variable-Volume Exhaust System Operational Concept, 428	
	34.5 34.6	VAV System Controls and Components, 429 VAV System Fan Controls and Components, 431	
	34.0	VAV System Part Controls and Components, 431 VAV System Duct Configurations, 434	
	J7.1	711 System Duct Configurations, 454	
35	Energy Conservation		
	35.1	Introduction, 436	
	35.2	Recent Trends, 437	

- 35.3 Exhaust Ventilation for Contamination Control, 440
- 35.4 Lighting, 44835.5 Thermal Insulation, 448
- 35.6 Humidity Control, 448
- 35.7 Evaporative Cooling, 449
- 35.8 Water Conservation, 449
- 35.9 Efficient Operating Strategies, 449

PART V		ADMINISTRATIVE PROCEDURES	451
36	Proje	ct Execution and Bidding Procedures	453
	36.1	Guiding Concepts, 453	
		Implementation, 454	
	36.3	Bid Form, 456	
		Contract, 457	
		Change Orders, 457	
		Construction Inspections, 458	
		Punch List, 458	
		Additional Testing and Acceptance, 458	
		Beneficial Occupancy, 459	
	36.10	Final Acceptance and Commissioning, 459	
37	Comn	nissioning and Final Acceptance Criteria	460
	37.1	Guiding Concepts, 460	
	37.2	Design, Construction, and Preoccupancy Checklists, 460	
	37.3	Heating, Ventilating, and Air-Conditioning, 462	
	37.4	Loss Prevention, Industrial Hygiene, and Personal Safety, 466	
	37.5	Project Commissioning, 467	
38	Sustai	nable Laboratory Design	471
	38.1	Introduction, 471	
	38.2	Laboratory Construction Materials, 472	
	38.3	Heating, Ventilating, and Air-Coniditioning, 474	
	38.4	Loss Prevention, Industrial Hygiene, and Personal Safety, 477	
		Miscellaneous Services, 477	
		Lighting, 478	
	38.7	Submetering, 479	
	38.8	Additional Background Material, 479	
DA	DT 1/1	APPENDIXES	481
TA.	KI VI	AFFENDIAES	401
	="	A Emergency Showers	483
	pendix		485
•	pendix		486
-	pendix	· ·	489
App	pendix		
		Laboratory Types	495
RE	REFERENCES		500
INI	INDEX		