

The Model Aquatic Health Code

The Annex



Release for
Final Public Comment

March 2014



U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Model Aquatic Health Code Complete Draft Version for the Second 60-day Review

**Posted for Public Comment on 03/28/2014
Currently Open for Public Comment that Closes on 05/27/2014**

The MAHC is posting the complete DRAFT version of the MAHC for a second 60-day public comment review period. Each MAHC module was revised and reposted after the first 60-day public comment period. These modules have been merged into a single document and we have attempted to correct inconsistencies and duplications that arose as part of the modular development process. This second review should allow reviewers to cross check between different sections of the MAHC to improve consistency and coherence. This draft will be revised again based on the public comments received and released as the MAHC 1st Edition. The MAHC organizers appreciate your patience with the review process and commitment to this endeavor as we all seek to produce the best aquatic health code possible.

This information is distributed solely for the purpose of pre-dissemination public comment under applicable information quality guidelines. It has not been formally disseminated by the Centers for Disease Control and Prevention. It does not represent and should not be construed to represent any agency determination or policy.

This document does not address all health and safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate health and safety practices and determine the applicability of regulatory limitations prior to each use.

MAHC Complete Draft Version Review Guidance

The **Model Aquatic Health Code (MAHC) Organizers** appreciate your willingness to review this DMAHC Complete DRAFT Version. Your unique perspectives and science-based suggestions will help ensure that the best available standards and practices for protecting aquatic public health are available for adoption by state and local environmental health programs. Please consult the Public Comment Process webpage (www.cdc.gov/healthywater/swimming/pools/mahc/comments.html) for guidance on how to submit public comments on this version of the MAHC. Read the “Review Guidance” below for details about this draft and submitting comments.

Reminder: please be as specific, complete, and succinct as possible in suggestions for improving this draft

Review Guidance:

- Please download and use the **MAHC Comment Form** (<http://www.cdc.gov/healthywater/swimming/pools/mahc/structure-content/>) to submit your detailed, succinct comments and suggested edits. Return your review form by 05/27/2014, as an email attachment to MAHC@cdc.gov.
 - **NOTE:** Only comments sent in this form will be accepted.
 - **Draft MAHC Section Number:** Provide specific citation of draft MAHC section where a change is needed.
 - **Recommended New Draft MAHC Section Language:** Provide specific amended language.
 - **Basis for Suggested Change:** Are these comments supported by published scientific studies, existing state or local CODES, or other references or editorial in nature?
 - **Comment Previously Addressed:** Using the Public Comment Tracking List, determine if your proposed comment has been previously addressed by the first 60-day round of public comment. Unless there is new, peer-reviewed, scientific data to support the change request, the MAHC committees strongly encourage submission of new comments that were not addressed during the previous comment period.
 - **Suggested Change Reference Citation:** Please provide the full publication citation information for basis of suggested change including notation of specific page number or section number. Mark Editorial, if no reference information is provided
- If part of a larger group or organization, please consolidate comments to speed the MAHC response time to public comments.
- The complete MAHC 1st Edition, with all of the individual 2nd 60-day public comment responses addressed and the public comment responses will be posted when completed.
- The published MAHC will be regularly updated through a collaborative all-stakeholder process.

Please address any questions you may have about MAHC or the review process to MAHC@cdc.gov. You may also request to be on the direct email list for alerts (“Get Email Updates” is in a box on the right hand side of the MAHC website (www.cdc.gov/healthywater/swimming/pools/mahc/index.html) or the Healthy Swimming website (www.cdc.gov/healthyswimming)).

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Thank you again, and we look forward to your help in this endeavor.

Sincerely,

Douglas C. Sackett, Director

MAHC Steering Committee

***Reviewer Note on MAHC Complete Draft Version
Section Numbering:***

Please use the specific section numbers to make your comments on this Model Aquatic Health Code Complete Draft Version.

Foreword

Reserved for final publication

Acknowledgments

Reserved for final publication

Table of Contents

Table of Contents	v
Information to Assist the User with the MAHC Format.....	xxx
Organization	xxx
Section Number	xxx
Title, Keyword, Phrase	xxx
Description.....	xxx
Module Abbreviations	xxx
1.0 Preface.....	31
1.1 Introduction.....	31
1.1.1 Rationale	31
1.1.2 Need for Further Guidance	31
1.1.3 Responsibility of User.....	31
1.1.4 Original Manufacturer Intent	31
1.1.5 Local Jurisdiction.....	31
1.2 Recreational Water-Associated Illness (RWI) Outbreaks and Injuries	31
1.2.1 RWI Outbreaks	31
1.2.2 Significance of <i>Cryptosporidium</i>	32
1.2.3 Drowning and Injuries	33
1.2.4 Pool Chemical-Related Injuries	33
1.3 Model Aquatic Health Code (MAHC)	33
1.3.1 Background.....	33
1.3.2 MAHC Vision and Mission	34
1.3.3 Best Available Practice	34
1.3.4 Process	34
1.3.5 Updating the MAHC.....	34
1.3.6 Authority.....	34
1.3.7 CDC Role.....	34
1.3.7.1 Public Health Role	34
1.3.7.2 Model Guidance	34
1.4 Public Health and Consumer Expectations	34
1.4.1 Industry & Government Responsibility	34
1.4.2 Swimmer Responsibility	34
1.5 Advantages of Uniform Guidance.....	34
1.5.1 Industry Agreement	34
1.5.2 MAHC Provisions.....	35
1.5.3 Aquatic Facility Requirements	35

1.6	Modification and Improvements in this MAHC Version	35
1.7	MAHC Adoption at State or Local Level.....	35
1.7.1	MAHC Adoption at State or Local Level	35
1.8	The MAHC Revision Process.....	35
1.8.1	MAHC Revisions	35
1.8.2	Future Revisions	35
1.9	Acknowledgements	36
1.9.1	Diversity.....	36
1.9.2	Dedication.....	36
1.9.3	Development.....	36
2.0	User Guide	37
2.1	Overview	37
2.1.1	New Users.....	37
2.1.2	Topic Presentations.....	37
2.2	MAHC Structure and Format	37
2.2.1	Numbering System.....	37
2.2.2	Title, Keyword, or Phrase Text.....	37
2.2.3	MAHC Requirement.....	37
2.2.4	Illustrations	37
2.2.5	Consistency Between Chapters 4.0 and 5.0.....	37
2.2.6	Conventions	37
2.2.7	Definitions.....	37
2.3	Annex.....	37
2.3.1	Rationale	37
2.3.2	Content.....	37
2.3.3	Bibliography	38
2.3.4	Appendices.....	38
3.0	Glossary of Acronyms and Terms Used in the MAHC	39
4.0	Design and Construction	40
4.0.1	Basic Design Considerations for Handling Particle Contamination Burden, Chlorine and Disinfectant Demand, and Disinfection By-Product Issues	40
4.0.1.1	Particle Contamination Burden	40
4.0.1.1.1	.....	40
4.0.1.1.2	.....	40
4.0.1.1.3	.....	40
4.0.1.2	Disinfectant Demand.....	40
4.0.1.2.1	.....	40
4.0.1.3	Chlorine Disinfectant Demand.....	41
4.0.1.3.1	.....	41
4.0.1.3.2	.....	41
4.0.1.3.3	.....	41

4.0.1.3.4	41
4.0.1.3.5	41
4.0.1.3.6	42
4.0.1.4 Disinfection By-product Issues	42
4.0.1.4.1	42
4.0.1.4.2	43
4.0.1.4.3	43
4.0.1.4.4	44
4.0.1.4.5	44
4.0.1.4.6	44
4.0.1.4.7	44
4.0.1.4.8	45
4.0.1.4.9	46
4.1 Plan Submittal	46
4.1.1 Plan Submittal REG	46
4.1.2 Content of Design Report REG	46
4.1.2.1 Basis of Design Report REG	46
4.1.2.1.1 Names / Addresses REG	46
4.1.2.2 Plans and Specifications REG	47
4.1.2.3 Technical Specifications REG	47
4.1.2.3.1 Accompany Drawings REG	47
4.1.2.3.2 Technical Details REG	47
4.1.3 Plan Approval REG	47
Review REG	47
4.1.3.1 New Construction REG	48
4.1.3.1.2 Plan Review Training REG	48
4.1.3.1.7 Plans Maintained REG	48
4.1.3.2 Non-Substantial Alterations REG	48
4.1.3.3 Replacements REG	48
Sample Form REG	48
4.1.4 Certificate of Compliance REG	48
4.1.4.4 Systems Commissioning REG	48
4.1.5 Construction Permits REG	49
4.1.5.4 Permit Denial REG	49
4.2 Materials	49
4.2.1 Pools D&C	49
4.2.1.2.1 Darker Colors D&C	49
4.2.1.2.3 Design Parameters D&C	49
4.2.1.4 Smooth Finish D&C	49
4.2.1.5 Slip Resistant D&C	49
4.2.2 Natatorium D&C	50
4.2.2.1 Interior Finish D&C	50
4.2.2.2 Condensation Prevention D&C	50
4.2.2.2.1 Cold Weather D&C	50
4.2.2.2.2 Paint or Coating D&C	50
4.2.2.3 Mechanical Systems D&C	50

4.2.2.3.3	Natatorium Air Pressure D&C.....	50
4.2.2.4	Natatorium Doors D&C	50
	Door Freezing.....	50
4.2.2.5	Natatorium Windows D&C.....	50
4.2.2.6	Natatorium Electrical Systems D&C	51
4.3	Equipment Standards.....	51
4.3.1	General D&C	51
4.3.1.1	Accredited Testing Facility D&C	51
4.3.2	Recirculation Systems and Equipment D&C.....	52
	Inlets D&C.....	52
	Overflow System / Gutters D&C	52
	Skimmers D&C.....	52
	Main Drain System D&C.....	52
	Multiport Valves D&C.....	52
	Face Piping D&C.....	52
	Diaphragm Valves D&C	53
	Check Valves D&C.....	53
	Fittings D&C.....	53
	Pipe D&C.....	53
	Pumps D&C	53
	Strainers D&C.....	53
	Gauges D&C.....	53
	Flow Meters D&C.....	53
4.3.2, cont.	Heaters D&C	54
	HVAC and Dehumidifiers D&C.....	54
	Solar Pool Heaters D&C	54
	Furnaces D&C.....	54
	Boilers D&C	54
	Gas-Fired Pool Heaters D&C.....	54
	Flues D&C.....	54
4.3.2, cont.	Filtration D&C.....	54
	Rapid Sand Filters D&C	54
	High-Rate Sand Filters D&C	54
	Precoat Filters D&C.....	54
	Filter Media D&C	55
	Cartridge Filters D&C.....	55
	Other Filter Types D&C.....	55
4.3.2, cont.	Disinfection Equipment D&C	55
	Mechanical Chemical Feeding Equipment D&C.....	55
	Ozone D&C	55
	Ultraviolet Light D&C	55
	In-line Electrolytic Chlorinator D&C	55
	Brine Batch Electrolytic Chlorine or Bromine Generator D&C	55
	Copper/Silver and Copper Ion Generator D&C.....	56
	Chemical Storage D&C.....	56
	Automated Controllers D&C	56

Water Quality Testing Device D&C	56
4.3.2, cont. Electrical D&C	56
National Electrical Code D&C.....	56
Lights D&C	56
4.3.2, cont. Deck Equipment D&C.....	56
Diving Boards and Platforms D&C	56
Starting Blocks D&C	56
Life Guard Chairs D&C	57
Ladders D&C	57
Handrail D&C	57
Stairs D&C.....	57
Handicapped Lifts D&C.....	57
Safety Covers D&C.....	57
4.4 Aquatic Venue Operation and Facility Maintenance	57
4.5 Aquatic Venue Structure	57
4.5.1 Design for Risk Management LG.....	57
4.5.2 Bottom Slope D&C.....	58
4.5.2.1 Parameters and Variance D&C	58
4.5.2.2 Under 5 feet D&C	58
4.5.2.4 Drain D&C	58
4.5.3 Access Ladders/Recessed Steps/Stairs	58
4.5.4 Pool Access/Egress D&C.....	58
4.5.4.1 Accessibility D&C	58
4.5.5 Stairs D&C.....	58
4.5.5.3 Deep Water D&C.....	58
4.5.6 Handrails D&C	58
4.5.6.5 ADA Accessibility D&C.....	58
4.5.7 Grab Rails D&C.....	59
4.5.8 Recessed Steps D&C	59
4.5.9 Ladders D&C	59
4.5.9.1 General Guidelines for Ladders D&C.....	59
4.5.9.2 Ladder Hand Rails D&C	59
ADA Accessibility D&C	59
4.5.9.2.4 Pool Wall D&C.....	59
4.5.9.2.7 Concentrated Load D&C	59
4.5.9.3 Ladder Treads D&C	59
4.5.10 Zero Depth (Sloped) Entries D&C	59
4.5.11 Disabled Access D&C.....	59
4.5.11.1 Conform to Guidelines D&C	59
4.5.12 Color and Finish D&C.....	59
4.5.12.1 White or Light Pastel D&C.....	59
4.5.12.1.1 Munsell Color Value D&C	60
4.5.13 Walls.....	60
4.5.14 Structural Stability D&C	60
4.5.15 Hand Holds D&C	61
4.5.16 Infinity Edges D&C.....	61

4.5.16.1	Perimeter Restrictions D&C.....	61
4.5.16.3	Handholds D&C.....	61
4.5.16.6	Maximum Height D&C.....	61
4.5.17	Underwater Benches D&C.....	61
4.5.17.1	Slip Resistant D&C.....	61
4.5.18	Underwater Ledges D&C.....	61
4.5.18.1	Slip Resistant D&C.....	61
4.5.18.4	Structural Support D&C.....	62
4.5.19	Underwater Shelves D&C.....	62
4.5.20	Depth Markers and Markings.....	62
4.5.20.1	Location of Depth Markings RM.....	62
4.5.20.1.2	Depth Measurements RM.....	62
4.5.20.1.3	Below Handhold RM.....	62
4.5.20.1.4	Coping or Deck.....	62
4.5.20.1.5	Read on Deck.....	62
4.5.20.1.6	25' Intervals.....	62
4.5.20.2	Construction / Size.....	62
4.5.20.2.1	Durable.....	62
4.5.20.2.2	Slip Resistant.....	63
4.5.20.2.3	Color and Height RM.....	63
4.5.20.2.4	Feet and Inches.....	63
4.5.20.3	Tolerance.....	63
4.5.20.3.1	Nearest 3 Inches.....	63
4.5.20.4	No Diving Markers.....	63
4.5.20.4.1	Depths D&C.....	63
4.5.20.5	Depth Marking at Break in Floor Slope D&C.....	65
4.5.20.5.1	Over 5 Feet D&C.....	65
4.5.20.5.2	Durable D&C.....	65
4.5.20.5.3	Safety Rope D&C.....	65
4.5.20.6	Dual Marking System RM.....	65
4.5.20.7	Non-traditional Aquatic Venues RM.....	65
4.5.20.8	Spa Depth Markers RM.....	65
4.5.20.9	Wading Pool Depth Markers RM.....	65
4.5.20.10	Movable Floor Depth Markers RM.....	66
4.5.21	Aquatic Venue Shell Maintenance [N/A].....	66
4.6	Indoor/Outdoor Environment.....	66
4.6.1	Lighting.....	66
4.6.1.1	General Requirements.....	66
4.6.1.2	Windows/Natural Light.....	66
4.6.1.2.1	Natural Lighting Methods D&C.....	66
4.6.1.3	Light Levels D&C.....	66
4.6.1.3.1	Minimum Levels D&C.....	66
4.6.1.4	Overhead Lighting RM.....	66
4.6.1.4.1	Artificial Lighting RM.....	66
4.6.1.5	Underwater Lighting RM.....	66
4.6.1.5.1	Minimum Requirement D&C.....	67

4.6.1.5.2	Dimmable Lighting D&C	68
4.6.1.6	Night Swimming with No Underwater Lights D&C	68
4.6.1.6.1	Minimum Requirements D&C.....	68
4.6.1.7	Emergency Lighting D&C	68
4.6.1.7.1	Emergency Egress Lighting D&C	68
4.6.1.8	Glare RM.....	68
4.6.1.8.1	Windows D&C.....	68
4.6.2	Indoor Aquatic Facility Ventilation.....	69
4.6.2.1	Purpose VEN.....	70
Chemical By-Products	VEN.....	70
Biological By-Products	VEN.....	71
4.6.2.2	Exemptions VEN.....	72
4.6.2.3	Indoor Aquatic Facility VEN	72
4.6.2.4	Mechanical Code VEN.....	72
4.6.2.5	ASHRAE 62.1 VEN.....	72
4.6.2.6	Air Handling System Design VEN	73
4.6.2.6.1	Mechanical Systems VEN	73
4.6.2.6.2	Design Factors and Performance Requirements VEN.....	73
4.6.2.6.3	Ventilation in Chemical Storage Space VEN	76
4.6.2.7	Performance Requirements for Air Handling Systems VEN.....	76
4.6.2.7.1	Minimum Outdoor Air VEN.....	76
4.6.2.7.2	System Alarm VEN	76
4.6.2.7.6	Relative Humidity/Dew Point VEN.....	77
4.6.2.7.8	Disinfection By-Product Removal VEN.....	77
4.6.2.7.11	Purge VEN.....	78
4.6.2.7.12	Air Handling System Filters VEN	78
4.6.2.7.6	Relative Humidity M&T.....	79
4.6.3	Electrical Systems and Components D&C	79
4.6.3.1	General Guidelines D&C	79
Wiring	D&C.....	79
Sealed Conduit	D&C	79
Electric Panels	D&C.....	80
Exposed Wiring	D&C.....	80
Metal Raceways	D&C	80
4.6.3.1.2	Natatoriums D&C	81
4.6.3.2	Electrical Equipment in Interior Chemical Storage Space D&C	81
Raceways	D&C.....	81
Sealed	D&C	81
Metal Raceways	D&C	82
Electronics	D&C.....	82
Light Switches	D&C.....	82
Permanent Electrical Devices	D&C.....	82
4.6.3.2.1	Wet and Corrosive D&C.....	82
4.6.3.2.2	Electrical Conduit D&C.....	82
4.6.3.2.3	Electrical Devices D&C.....	83
4.6.3.2.4	Protected Against Breakage D&C	83

4.6.4	Pool Water Heating.....	83
	Evaporation Control D&C	83
	Uncontrolled Condensation D&C	83
	Evaporation Rate D&C	84
	Space Heating D&C.....	84
	Seasonal Disabling D&C	84
	Combustion Heaters D&C	85
4.6.4.1	High Temperature D&C.....	85
4.6.4.4	Equipment Room Requirements D&C.....	86
4.6.5	First Aid Room	86
4.6.5.1	Station Design LG.....	86
4.6.6	Emergency Exit.....	86
4.6.7	Drinking Fountains D&C.....	86
4.6.7.1	Provided D&C.....	86
4.6.8	Garbage Receptacles.....	87
4.6.9	Food and Drink Concessions	87
4.6.10	Spectator Areas D&C	87
4.6.10.1	Within Aquatic Facility Enclosure D&C	87
4.6.10.3	Balcony D&C.....	87
4.6.10.4	Bleachers D&C	87
4.7	Recirculation and Water Treatment.....	87
4.7.1	Recirculation Systems and Equipment	87
4.7.1.1	General R&F	87
	Rationale for Prescriptive Approach R&F.....	87
	Reasons to Exceed the Minimum Standards R&F.....	87
	Hydraulic Flexibility Recommendation R&F.....	88
4.7.1.2	Combined Aquatic Venue Treatment R&F.....	88
4.7.1.3	Inlets R&F.....	89
4.7.1.3.1	General R&F.....	89
4.7.1.3.2	Floor Inlets R&F	89
4.7.1.3.3	Wall Inlets R&F.....	90
4.7.1.4	Overflow Systems/Gutters R&F	91
4.7.1.4.1	General R&F.....	91
4.7.1.4.2	Gutter Size and Shape R&F.....	91
4.7.1.4.3	Gutter Outlets R&F.....	92
4.7.1.4.4	Surge Tank Capacity R&F.....	92
4.7.1.4.5	Tolerances R&F.....	92
4.7.1.4.6	Makeup Water System R&F.....	93
4.7.1.5	Skimmers R&F.....	93
4.7.1.5.1	General R&F.....	93
4.7.1.5.2	Skimmer Location R&F.....	94
4.7.1.5.3	Skimmer Flow Rate R&F	94
4.7.1.5.4	Control R&F	94
4.7.1.5.5	Tolerances R&F.....	94
4.7.1.5.6	Testing R&F.....	94
4.7.1.6	Submerged Suction Outlet R&F	95

4.7.1.6.1	General R&F.....	95
4.7.1.6.2	Number and Spacing R&F.....	95
4.7.1.6.3	Tank Connection R&F.....	95
4.7.1.6.4	Flow Distribution and Control R&F.....	95
4.7.1.6.5	Flow Velocities R&F.....	96
4.7.1.7	Piping R&F.....	96
4.7.1.7.1	Design R&F.....	96
4.7.1.7.2	Velocity in Pipes R&F.....	96
4.7.1.7.3	Drainage and Installation R&F.....	97
4.7.1.7.4	Piping and Component Identification R&F.....	98
4.7.1.7.5	Testing R&F.....	98
4.7.1.8	Strainers and Pumps R&F.....	98
4.7.1.8.1	Strainers R&F.....	98
4.7.1.8.2	Pumping Equipment R&F.....	98
4.7.1.8.3	Operating Gauges R&F.....	99
4.7.1.9	Flow Measurement and Control R&F.....	99
4.7.1.9.1	Flow Meters R&F.....	99
4.7.1.10	Flow Rates/Turnover R&F.....	100
4.7.1.10.1	Maximum Allowable Flow Rates R&F.....	100
4.7.1.10.2	Calculated R&F.....	100
4.7.1.10.4	Turnover Times R&F.....	104
4.7.1.10.6	Flow Turndown System R&F.....	105
4.7.2	Filtration.....	106
	System Design R&F.....	106
	Water Quality R&F.....	106
	Pathogen Removal R&F.....	107
	<i>Cryptosporidium</i> R&F.....	107
	3-Log Reduction R&F.....	109
	Explanation R&F.....	110
	Review of Recreational Water Filtration Research Findings R&F.....	111
	Sand Filters R&F.....	111
	Filtration Systems R&F.....	112
	Filtration Products R&F.....	113
	Brief Historical Review of Water Filtration Practices for Aquatic Venues R&F.....	113
	1920's R&F.....	113
	Increased Headloss Development Rates R&F.....	114
	Pressure Development R&F.....	114
4.7.2.2	Granular Media Filters R&F.....	114
4.7.2.2.1	General R&F.....	114
4.7.2.2.2	Filter Location and Spacing R&F.....	114
4.7.2.2.3	Filtration and Backwashing Rates R&F.....	115
4.7.2.2.4	Filter Media Depth Requirement R&F.....	118
4.7.2.2.5	Differential Pressure Measurement R&F.....	122
4.7.2.2.6	Coagulant Injection Equipment R&F.....	122
4.7.2.3	Precoat Filters R&F.....	124
4.7.2.3.1	General R&F.....	124

4.7.2.3.2	Filtration Rates R&F.....	124
4.7.2.3.3	Precoat Media Introduction System R&F.....	125
4.7.2.3.4	Continuous Filter Media Feed Equipment R&F.....	125
4.7.2.4	Cartridge Filters R&F.....	125
4.7.2.4.1	Listed R&F.....	125
4.7.2.4.2	Filtration Rates R&F.....	126
4.7.2.4.3	Elements R&F.....	126
4.7.2.4.4	Spare Cartridge R&F.....	126
4.7.3	Disinfection and pH Control.....	126
	Disinfection and Indoor Air Quality DWQ.....	126
	Proper Chemical Use DWQ.....	127
	High Chloramines DWQ.....	127
	Shock Oxidizer DWQ.....	127
	Swimmer Education DWQ.....	127
	Reduce and Minimize Impact DWQ.....	128
4.7.3.1	Chemical Addition Methods R&F.....	128
4.7.3.2	Feed Equipment R&F.....	128
4.7.3.2.1	General R&F.....	128
4.7.3.2.2	Sizing of Disinfection Equipment R&F.....	128
4.7.3.2.3	Introduction of Chemicals R&F.....	128
4.7.3.2.4	Compressed Chlorine Gas R&F.....	128
4.7.3.2.5	Types of Feeders R&F.....	128
4.7.3.2.6	Salt Electrolytic Chlorine Generators, Brine Electrolytic Chlorine or Bromine Generators R&F.....	128
4.7.3.2.7	Feeders for pH Adjustment R&F.....	129
4.7.3.2.8	Automated Controllers R&F.....	129
4.7.3.3	Secondary Disinfection Systems DWQ.....	129
4.7.3.3.1	General Requirements DWQ.....	129
	Facilities DWQ.....	130
4.7.3.3.2	3-log Inactivation and Oocyst Reduction DWQ.....	130
4.7.3.3.3	Ultraviolet Light Systems DWQ.....	134
	Validation Factor DWQ.....	134
	Transmissivity (Transmission) DWQ.....	134
4.7.3.3.4	Ozone Disinfection DWQ.....	136
4.7.3.4	Supplemental Treatment Systems DWQ.....	138
4.7.3.4.1	General Requirements DWQ.....	138
4.7.3.4.2	Ultraviolet Light DWQ.....	138
4.7.3.4.3	Ozone DWQ.....	138
4.7.3.4.4	Copper/Silver Ion System DWQ.....	138
4.7.3.4.5	Ultraviolet Light / Hydrogen Peroxide Systems DWQ.....	139
4.7.3.5	Testing for Water Quality and Circulation M&T.....	139
4.7.3.6	Microbiological Testing Equipment M&T.....	142
4.7.4	Water Replenishment R&F.....	149
	Water Replenishment System R&F.....	149
4.7.4.1	Local Authority R&F.....	149
4.7.4.2	Discharge and Measure R&F.....	150

Alternate Systems R&F	150
4.7.5 Spas	151
4.7.5.1 General R&F	151
4.7.5.2 Flow Rates / Turnover Times R&F.....	151
4.7.5.3 Filtration System Inlets R&F	151
4.7.5.4 Jet System Inlets R&F.....	151
4.8 Decks and Equipment.....	151
4.8.1 Decks.....	151
4.8.1.1 General Standards for All Decks D&C	151
4.8.1.1.2 Lifeguard Placement and Safety Considerations LG.....	151
4.8.1.1.6 Concrete Decking D&C.....	151
4.8.1.2 Standards for Perimeter Decks D&C	151
4.8.1.2.1 Impervious D&C.....	151
4.8.1.3 Drains D&C.....	152
4.8.1.3.1 Slope D&C.....	152
4.8.1.3.3 Cross Connection Control D&C	152
4.8.1.4 Materials/Slip Resistance RM.....	152
4.8.1.4.2 Slip Resistance D&C	152
4.8.1.4.3 Carpet D&C	152
4.8.1.4.4 Wood D&C	153
4.8.1.4.5 Dry Deck D&C	153
4.8.1.4.6 Landscaping D&C	153
4.8.1.5 Deck Size/Width RM	154
4.8.1.5.2 Fixed Equipment D&C	154
4.8.1.5.3 Circulation Path D&C.....	154
4.8.1.6 Wing Walls or Peninsulas D&C.....	154
4.8.1.6.1 No Perimeter Deck D&C	154
4.8.1.6.2 Perimeter Overflow System D&C	154
4.8.1.6.3 Pool Perimeter D&C.....	155
4.8.1.6.4 Normal Operating Water Level D&C.....	155
4.8.1.6.5 Deck Drainage D&C.....	155
4.8.1.7 Islands D&C.....	155
4.8.1.7.7 Minimum Clearance D&C.....	155
4.8.1.8 Heated Decks D&C.....	155
4.8.1.8.1 Freeze Protection D&C.....	155
4.8.1.9 Hose Bibbs D&C.....	155
4.8.2 Diving Boards and Platforms D&C	155
4.8.2.1 Diving Envelope D&C.....	155
4.8.2.1.1 Conforms D&C.....	155
4.8.2.2 Steps and Guardrails D&C.....	156
4.8.3 Starting Platforms D&C.....	156
4.8.3.1 Conform to Standard Codes D&C	156
Spinal Cord Injury Data.....	156
Future Directions and Research: D&C	157
4.8.4 Deck Slides	158
4.8.5 Lifeguard and Safety Related Equipment.....	158

4.8.5.1	Safety Equipment Required at all Aquatic Facilities LG.....	158
4.8.5.1.1	Emergency Communication Equipment LG.....	158
4.8.5.1.2	First Aid Equipment.....	158
4.8.5.1.3	Signage.....	158
4.8.5.2	Safety Equipment Required at Aquatic Facilities with Lifeguards.....	158
4.8.5.2.1	Lifeguard Chair and Stand Placement LG.....	158
4.8.5.2.2	Lifeguard Chair and Stand Design LG.....	159
4.8.5.2.3	UV Protection for Chairs and Stands LG.....	159
4.8.6	Barriers and Enclosures.....	159
4.8.6.1	General Requirements D&C.....	159
4.8.6.2	Construction Requirements D&C.....	159
4.8.6.2.1	Local Code D&C.....	159
4.8.6.2.4	Building Emergency Exit D&C.....	159
4.8.6.2.7	Height D&C.....	160
4.8.6.3	Gates and Doors D&C.....	160
4.8.6.3.6	Absence of Local Building Codes D&C.....	160
4.8.6.4	Indoor Aquatic Venues D&C.....	160
4.8.6.4.3	Indoor and Outdoor Aquatic Venues D&C.....	160
4.8.6.4.4	Wall Separating D&C.....	160
4.8.6.5	Multiple Aquatic Venues D&C.....	160
4.8.6.5.2	Wading Pools D&C.....	160
4.8.7	Aquatic Venue Cleaning System.....	161
4.8.7.1	No Hazard D&C.....	161
4.8.7.7	GFCI Connection D&C.....	161
4.8.7.8	Power Cord D&C.....	161
4.9	Filter/Equipment Room.....	161
4.9.1	Equipment Room D&C.....	161
4.9.1.1	General Requirements D&C.....	161
4.9.1.1.3	Opening D&C.....	161
4.9.1.2	Construction D&C.....	161
4.9.1.3	Electrical D&C.....	161
4.9.1.4	Ventilation D&C.....	161
4.9.1.4.1	Code Conformance D&C.....	161
4.9.1.5	Markings D&C.....	162
4.9.1.5.1	Piping Identified D&C.....	162
4.9.1.6	Equipment Rooms Containing Combustion Equipment D&C.....	162
	Installed D&C.....	162
	Increased Ventilation D&C.....	162
	Noxious Gasses D&C.....	162
	Plenum Room D&C.....	163
	Lowered Room Pressure D&C.....	163
4.9.1.7	Separation from Chemical Storage Spaces D&C.....	163
4.9.1.7.1	Equipment D&C.....	163
4.9.1.7.2	Doors and Openings D&C.....	164
4.9.1.7.3	Natatorium Access D&C.....	165
4.9.1.8	Other Equipment Room Guidance D&C.....	166

4.9.1.8.1	Access Space D&C	166
4.9.1.8.2	Adequate Space D&C	166
4.9.1.8.3	Minimize Hazards D&C	167
4.9.1.8.4	Refrigeration Equipment D&C	167
4.9.2	Chemical Storage Spaces D&C	167
4.9.2.1	Outdoor / Indoor Storage D&C	168
4.9.2.1.1	Stored Outdoors D&C	168
4.9.2.1.2	Minimize Vapors D&C	168
4.9.2.1.3	Dedicated Space D&C	168
4.9.2.1.4	Safe Spaces D&C	168
4.9.2.1.5	Additional Space D&C	169
4.9.2.1.6	Eyewash D&C	169
4.9.2.2	Construction D&C	169
4.9.2.2.1	Foreseeable Hazards D&C	169
4.9.2.2.2	Protected D&C	169
4.9.2.2.3	Floor D&C	169
4.9.2.2.4	Minimize Fumes D&C	169
4.9.2.2.5	Surfaces D&C	169
4.9.2.2.6	No Openings D&C	170
4.9.2.3	Exterior Chemical Storage Spaces D&C	170
4.9.2.3.1	Outdoor Equipment D&C	170
4.9.2.3.2	Fencing D&C	170
4.9.2.3.3	Gate D&C	170
4.9.2.4	Chemical Storage Space Doors D&C	170
4.9.2.4.1	Signage D&C	170
4.9.2.4.2	Emergency Egress D&C	170
4.9.2.4.3	Interior Door D&C	171
4.9.2.4.4	Equipment Space D&C	171
4.9.2.4.5	Interior Opening D&C	171
4.9.2.5	Interior Chemical Storage Spaces D&C	172
4.9.2.5.1	No Air Movement D&C	172
4.9.2.5.2	Electrical Conduit System D&C	172
4.9.2.6	Air Ducts in Interior Chemical Storage Spaces D&C	173
4.9.2.6.1	No Air Movement D&C	173
4.9.2.7	Pipes and Tubes in Interior Chemical Storage Spaces D&C	173
4.9.2.8	Combustion Equipment in Interior Chemical Storage Spaces D&C	173
4.9.2.8.1	Installed D&C	173
4.9.2.9	Electrical Equipment in Chemical Storage Spaces D&C	174
4.9.2.10	Ozone Rooms D&C	174
4.9.2.11	Gaseous Chlorination Space D&C	174
4.9.2.12	Windows in Chemical Storage Spaces D&C	174
4.9.2.12.1	Not Required D&C	174
4.9.2.12.2	Requirements D&C	174
4.9.2.13	Sealing and Blocking Materials D&C	174
4.10	Hygiene Facilities	174
4.10.1	General	174

4.10.1.2	Hygiene Facilities HYG	174
4.10.1.5	Bather Load HYG	176
4.10.2	Location	176
4.10.2.1	Distance HYG	176
4.10.2.2	Diaper-Aged Children HYG	176
4.10.3	Design and Construction HYG.....	176
4.10.3.1	Floors HYG	177
4.10.3.2	Floor Base HYG.....	177
4.10.3.3	Floor Drains HYG.....	177
4.10.3.3.1	Opening Grill Covers HYG	177
4.10.3.3.2	Sloped to Drain HYG.....	177
4.10.3.5	Hose Bibb HYG	177
4.10.4	Plumbing Fixture Requirements HYG	177
4.10.4.1.1	Protected HYG.....	177
4.10.4.1.3	Toilet Counts HYG.....	177
4.10.4.2	Cleansing Showers HYG	179
4.10.4.2.1	Count HYG	179
4.10.4.2.5	Location HYG.....	179
4.10.4.2.8	Exemption HYG	179
4.10.4.2.6	Enclosed HYG	179
4.10.4.3	Rinse Showers HYG	180
4.10.4.3.3	Floor Sloped HYG.....	180
4.10.4.3.4	Large Aquatic Facilities HYG	180
4.10.4.3.5	Beach Entry HYG.....	180
4.10.4.3.6	Lazy River HYG.....	180
4.10.4.3.7	Waterslide HYG.....	180
4.10.4.4	All Showers HYG	180
4.10.4.4.1	Exceptions HYG	180
4.10.4.5	Diaper-Changing Stations HYG.....	181
4.10.4.5.2	Hand Wash Station HYG.....	181
4.10.4.5.3	Portable HYG.....	181
4.10.4.5.4	Conform HYG	181
4.10.4.5.5	Unisex HYG.....	182
4.10.4.5.6	Trash Can HYG	182
4.10.4.6	Non-Plumbing Fixture Requirements HYG.....	182
4.10.4.6.4	Lockers HYG.....	182
4.10.4.6.6	Dryers/Paper Towels HYG.....	182
4.10.5	Provision of Suits, Towels, and Shared Equipment	182
4.10.5.1	Adequate Space HYG	182
4.10.6	Foot Baths HYG	183
4.10.6.1	Prohibited HYG.....	183
4.10.7	Sharps HYG.....	183
4.10.7.1	Container HYG	183
4.11	Water Supply / Wastewater Disposal.....	183
4.11.1	Water Supply D&C.....	183
4.11.1.1.1	Other Sources D&C	183

4.11.1.1.2	Condensate / Reclaimed Water D&C	183
4.11.1.2.1	Refill Pool D&C	184
4.11.2	Fill Spouts.....	184
4.11.2.1	Hazard D&C.....	184
4.11.3	Cross-Connection Control.....	184
4.11.3.1	Protected D&C	184
4.11.4	Deck Drains and Rinse Showers	185
4.11.5	Sanitary Wastes	185
4.11.6	Pool Wastewater.....	185
4.11.6.2	Ground Surface D&C.....	185
4.11.6.4	Prohibit R&F.....	185
4.12	Special Venues.....	186
4.12.1	Spas.....	186
4.12.1.2	Maximum Water Depth D&C	186
4.12.1.3	Handholds D&C.....	186
4.12.1.5	Perimeter Deck D&C	186
4.12.1.5.4	Elevated Spas D&C	186
4.12.1.7	Temperature D&C.....	186
4.12.1.14	Timers D&C.....	187
4.12.1.15	Emergency Shutoff D&C.....	187
4.12.2	Water Slides and Catch Pools.....	187
4.12.2.1	Design and Construction D&C.....	187
4.12.2.1.1	Additional Provisions D&C	187
4.12.2.2	Flumes D&C	187
4.12.2.3	Flume Exits D&C.....	187
4.12.2.4	Exit into Catch Pools D&C	187
4.12.2.5	Catch Pools D&C	187
4.12.2.6	Decks D&C	187
4.12.2.7	Means of Access D&C	187
4.12.2.8	Slide Run-outs D&C.....	187
4.12.2.9	Drop Slides D&C	187
4.12.2.10	Pool Slides D&C.....	188
4.12.2.11	Signage D&C	188
4.12.3	Wave Pools.....	188
4.12.3.1	General D&C.....	188
4.12.3.2	Access D&C	188
4.12.3.3	Safety D&C	188
4.12.3.3.3	No Diving Signs D&C.....	188
4.12.3.4	Water Quality D&C.....	188
4.12.4	Therapy Pools.....	188
4.12.5	Leisure Rivers.....	188
4.12.5.1	General D&C.....	188
4.12.5.2	Access and Egress D&C	188
4.12.5.2.1	Means D&C	188
4.12.5.2.3	Deck D&C	188
4.12.5.2.4	Bridges D&C	189

4.12.5.3	Water Quality D&C.....	189
4.12.5.4	Safety D&C	189
4.12.6	Moveable Floors	189
4.12.6.1	General D&C.....	189
4.12.6.2	Slip Resistance D&C.....	189
4.12.6.3	Safety D&C	189
4.12.6.3.1	Not Continuous D&C	189
4.12.6.3.2	Underside D&C	189
4.12.6.4	Movement D&C.....	189
4.12.6.4.1	Speed D&C	189
4.12.6.5	Water Depth and Markings D&C.....	190
4.12.7	Bulkheads	190
4.12.7.3	Entrapment D&C.....	190
4.12.7.6	Gap D&C.....	190
4.12.7.7	Handhold D&C	190
4.12.7.10	Width D&C	190
4.12.7.10.1	Starting Platforms D&C.....	190
4.12.8	Interactive Water Play Venues	190
4.12.8.3	Sloped D&C	190
4.12.8.10	Hazard D&C.....	191
4.12.8.12	Signage D&C	191
4.12.9	Wading Pools.....	191
4.12.9.2	Barrier D&C.....	191
4.12.9.2.2	Shallow Water D&C.....	191
5.0	Operation and Maintenance	192
5.1	Plan Submittal.....	192
5.2	Materials	192
5.2	Inspections.....	192
5.2.1	Preoperational Inspections	192
5.2.2	Exemptions	192
5.2.3	Variances.....	192
5.2.3.1	Variance Authority REG.....	192
5.2.4	Variance Requests.....	192
5.2.4.3.1	Hearing REG.....	192
5.3	Equipment Standards.....	192
5.4	Aquatic Venue Operations and Facility Maintenance	192
5.4.1	Closure and Reopening.....	192
5.4.1.1	Short Closures FMO.....	192
5.4.1.1.1	Short Closures FMO	192
5.4.1.1.2	Safe Condition FMO.....	193
5.4.1.2	Long Closures FMO.....	193
5.4.1.2.1	Drain / Cover FMO.....	193
5.4.1.2.1	Reopening FMO.....	194

5.4.2	Preventive Maintenance Plan FMO	194
5.4.2.1	Written Plan FMO	194
5.4.2.2	Facility Documentation FMO	194
5.4.2.2.2	Equipment Inventory FMO.....	194
5.4.3	General Operations	195
5.5	Aquatic Venue Structure (Shell).....	195
5.6	Indoor/Outdoor Environment	195
5.6.1	Lighting.....	195
5.6.1.1	Lighting Maintained FMO	195
5.6.1.1.1	Light Levels FMO.....	195
5.6.1.1.2	Main Drain Visible FMO.....	196
5.6.1.2	Glare FMO	196
5.6.1.2.1	Assessments FMO	196
5.6.2	Indoor Aquatic Facility Ventilation	196
5.6.2.8	Combined Chlorine Reduction VEN.....	196
5.6.3	Electrical	197
5.6.3.1	Electrical Repairs FMO.....	197
5.6.3.1.1	Local Codes FMO.....	197
5.6.3.2	Electrical Receptacles FMO.....	197
5.6.3.2.2	Repairs FMO.....	197
5.6.3.3	Ground-Fault Circuit Interrupter FMO	198
5.6.3.3.1	Manufacturer’s Recommendation FMO	198
5.6.3.4	Grounding FMO.....	200
5.6.3.5	Bonding FMO	201
5.6.3.6	Extension Cords FMO.....	201
5.6.3.6.3	Exception FMO.....	201
5.6.3.6.6	Compliance FMO.....	201
5.6.3.7	Portable Electric Devices FMO.....	201
5.6.3.8	Communication Devices and Dispatch Systems FMO	201
5.6.4	Facility Heating.....	201
5.6.4.1	Facility Heating FMO	201
5.6.4.1.1	Maintenance and Repair FMO.....	201
5.6.4.1.2	Defects FMO.....	201
5.6.4.1.3	Temperature FMO	201
5.6.4.2	Water Heating FMO.....	202
5.6.5	First Aid Room	202
5.6.6	Emergency Exit.....	202
5.6.7	Plumbing.....	202
5.6.7.1	Water Supply FMO	202
5.6.7.1.2	Availability FMO.....	202
5.6.7.2	Drinking Fountains FMO.....	202
5.6.7.3	Waste Water FMO	202
5.6.7.4	Water Replenishment R&F	202
5.6.7.4.1	Volume R&F.....	202
5.6.8	Solid Waste	203
5.6.8.1	Storage Receptacles FMO	203

5.6.8.2	Disposal FMO	203
5.6.9	Decks FMO	203
5.6.9.1	Food Preparation and Consumption FMO	203
5.6.9.1.2	Eating & Drinking FMO	203
5.6.9.2	Glass FMO	203
5.6.9.3	Deck Maintenance FMO	204
5.6.9.3.1	Free From Obstructions FMO.....	204
5.6.9.3.3	Vermin FMO.....	204
5.6.9.3.4	Original Design FMO	204
5.6.10	Aquatic Facility Maintenance.....	204
5.6.10.1	Diving Boards and Platforms	204
5.6.10.1.1	Slip-Resistant Finish FMO	204
5.6.10.2	Steps and Guardrails.....	204
5.6.10.3	Starting Blocks	204
5.6.10.4	Water Slides	204
5.6.10.5	Fencing and Barriers	204
5.6.10.6	Aquatic Facility Cleaning FMO.....	204
5.7	Recirculation and Water Treatment.....	204
5.7.1	Recirculation Systems and Equipment	204
5.7.1.1	General R&F	204
5.7.1.1.3	Gutter/ Skimmer Pools R&F.....	204
5.7.1.2	Combined Aquatic Venue Treatment R&F.....	205
5.7.1.3	Inlets R&F.....	205
5.7.1.4	Surface Skimming Devices R&F.....	206
5.7.1.5	Submerged Drains/Suction Outlet Covers or Gratings R&F.....	206
5.7.1.6	Piping R&F	206
5.7.1.7	Strainers and Pumps R&F.....	206
5.7.1.8	Flow Meters R&F.....	206
5.7.1.9	Flow Rates/Turnovers R&F	206
5.7.2	Filtration.....	206
5.7.2.1	Granular Media Filters R&F	206
5.7.2.1.4	Backwashing Frequency R&F.....	206
5.7.2.1.7	Filtration Enhancing Products R&F.....	206
5.7.2.2	Precoat Filters R&F.....	207
5.7.2.2.2	Precoating R&F	207
5.7.2.2.3	Operation R&F.....	207
5.7.2.2.4	Cleaning R&F	207
5.7.2.2.6	Bumping R&F.....	207
5.7.2.2.7	Filter Media R&F.....	208
5.7.2.2.8	Water Clarity and Visibility R&F.....	209
5.7.2.3	Cartridge Filters R&F.....	209
5.7.2.3.1	NSF Standards R&F	209
5.7.2.3.2	Filtration Rates R&F.....	209
5.7.2.3.3	Filter Elements R&F.....	210
	To clean the cartridges:.....	210
5.7.3.	Disinfection.....	211

5.7.3.1	Primary Disinfectants DWQ	211
5.7.3.1.1	Chlorine (Ca/Na/Li Hypochlorite) DWQ	211
	Maximum FAC DWQ	213
5.7.3.1.2	Bromine DWQ.....	215
	Bromates DWQ.....	217
	Disinfection DWQ.....	217
	Bromamines DWQ.....	218
5.7.3.1.3	Stabilizers.....	220
5.7.3.1.4	Compressed Chlorine Gas R&F.....	225
5.7.3.1.5	Salt Electrolytic CHLORINE Generators, Brine Electrolytic CHLORINE or Bromine Generators R&F.....	225
5.7.3.2	Secondary or Supplemental Treatment Systems DWQ	226
5.7.3.2.1	Ultraviolet Light DWQ.....	227
5.7.3.2.2	Ozone DWQ.....	227
5.7.3.2.3	Copper / Silver Ions DWQ.....	227
5.7.3.3	Other Sanitizers, Disinfectants, or Chemicals DWQ	228
	Hydrogen Peroxide DWQ.....	229
5.7.3.3.1	Chlorine Dioxide DWQ.....	229
5.7.3.3.2	Other Aquatic Venue Water Treatment Products DWQ.....	230
	Clarifiers, Flocculants, and Defoamers DWQ	230
5.7.3.4	pH DWQ	231
5.7.3.5	Feed Equipment.....	232
5.7.3.5.7	Gas Feed Systems R&F	232
5.7.3.6	Testing for Water Quality and Circulation M&T.....	232
5.7.3.7	Automated Controllers	232
5.7.3.8	Microbiological Testing Equipment.....	232
5.7.3.9	Filtration and Water Treatment Equipment.....	232
5.7.4	Water Sample Collection and Testing	232
5.7.4.1	Sample Collection	233
5.7.4.2	Routine Samples.....	233
5.7.4.3	Bulk Water Sample	233
5.7.4.3.3	Aquatic Venue Water Chemical Balance	233
5.7.4.3.4	Source (fill) Water DWQ.....	240
5.7.4.4	Saturation Index for Aquatic Venues.....	240
5.7.4.4.1	Water Balance Determination DWQ.....	240
5.7.4.4.2	Langelier Index Conversion Chart DWQ.....	241
	Ryznar Stability Index (RSI) DWQ.....	243
5.7.4.5	Water Temperature DWQ	244
5.7.4.5.2	Maximum Temperature RM	247
5.7.5	Water Quality Chemical Testing Frequency.....	248
5.7.5.1	Chemical Levels M&T.....	249
5.7.6	Water Clarity.....	249
5.8	Decks and Equipment.....	249
5.8.1	Spectator Areas	249
5.8.1.1	Cross-Connection Control RM.....	249
5.8.1.2	Materials/Slip Resistance RM.....	249

5.8.1.2.3	Tripping Hazards RM	249
5.8.1.3	Deck Size/Width	250
5.8.2	Diving Boards and Platforms.....	250
5.8.3	Starting Blocks.....	250
5.8.4	Deck Slides	250
5.8.5	Lifeguard and Safety Related Equipment.....	250
5.8.5.1	Equipment Inspection and Maintenance LG.....	250
5.8.5.2	Safety Equipment Required at All Aquatic Facilities LG.....	250
5.8.5.2.1	Communication Equipment LG.....	250
5.8.5.2.2	First Aid Equipment LG	251
5.8.5.2.3	Signage.....	252
5.8.5.3	Safety Equipment Required at Aquatic Facilities with Lifeguards LG	253
5.8.5.3.1	UV Protection for Chairs and Stands LG	253
5.8.5.3.2	Spinal Injury Board LG	253
5.8.5.3.3	Rescue Tube Immediately Available LG.....	254
5.8.5.3.4	Rescue Tube on Person LG.....	254
5.8.5.3.5	Identifying Uniform LG.....	255
5.8.5.3.6	Signal Device LG.....	255
5.8.5.3.7	Sun Blocking Methods LG	255
5.8.5.3.8	Polarized Sunglasses LG.....	256
5.8.5.3.9	Personal Protective Equipment LG.....	256
5.8.5.3.10	Rescue Throwing Device LG.....	257
5.8.5.3.11	Reaching Pole LG	257
5.8.5.4	Safety Equipment Required at Aquatic Facilities without Lifeguards LG	257
5.8.5.4.1	Throwing Device LG	257
5.8.5.4.2	Reaching Pole LG	257
5.8.5.4.3	CPR Posters LG	258
5.8.5.4.4	Imminent Hazard Sign LG.....	258
5.8.5.4.5	Sign for Conditions When Qualified Lifeguard is Required LG.....	258
5.9	Filter/Equipment Room	258
5.9.1.1	Local Codes RM.....	258
5.9.1.2	OSHA and EPA RM	259
5.9.1.3	MSDS RM.....	259
5.9.1.5	Protected RM.....	260
5.9.1.6	No Mixing RM.....	260
5.9.1.7	Ignition Sources RM	260
5.9.1.9	Lighting RM.....	261
5.9.1.10	PPE RM.....	261
5.10	Hygiene Facilities.....	261
5.10.1	General.....	261
5.10.2	Location [N/A]	261
5.10.3	Bathroom Design [N/A]	261
5.10.4	Fixture Requirements	261
5.10.4.1	General Requirements HYG	261
5.10.4.1.1	Cleaned and Sanitized HYG	261
5.10.4.2	Cleansing Showers HYG	262

5.10.4.3	Rinse Showers HYG	262
5.10.4.3.4	No Soap HYG	262
5.10.4.4	All Showers HYG	262
5.10.4.5	Diaper-Changing Stations HYG.....	262
5.10.4.5.1	Cleaned HYG.....	262
5.10.4.6	Non-Plumbing Fixture Requirements HYG.....	262
5.10.4.6.4	Floor Coverings HYG.....	262
5.10.5	Provision of Suits, Towels, and Shared Equipment	262
5.10.5.1	Towels HYG	262
5.10.5.3	Shared Equipment Cleaned and Sanitized HYG.....	263
5.10.5.4	Other Equipment HYG.....	263
5.11	Water Supply/ Wastewater Disposal.....	264
5.12	Special Requirements for Specific Venues	264
5.12.1	Water Slides.....	264
5.12.2	Wave Pools.....	264
5.12.3	Moveable Floors	264
5.12.4	Bulkheads	264
5.12.5	Interactive Water Aquatic Venues.....	264
5.12.6	Wading Pools.....	264
5.12.7	Spas.....	264
5.12.7.5	Water Replacement R&F	264
6.0	Policies and Management.....	265
6.0.1	Staff Training.....	265
6.0.1.8	Body Fluid Exposure RM	265
6.1.1	Operator Qualifications and Certification.....	265
6.1.2	Essential Topics in Qualified Operator Training Courses OT.....	266
6.1.2.1	Course Content OT.....	267
6.1.2.1.1	Water Disinfection OT.....	267
6.1.2.1.2	Water Chemistry	268
6.1.2.1.3	Mechanical Systems OT	268
6.1.2.1.4	Health and Safety OT.....	268
6.1.2.1.5	Operations OT.....	269
6.1.3	General Requirements for Training Courses	270
6.1.3.3	Course Length OT.....	270
6.1.3.4	Instructor Requirements OT.....	270
6.1.3.5	Final Exam OT.....	270
6.1.3.6	Course Certificates OT.....	271
6.1.3.7	Continuing Education OT	271
6.1.3.8	Certificate Renewal OT.....	271
6.1.3.9	Certificate Suspension and Revocation OT	271
6.1.3.10	Additional Training or Testing OT	272
6.1.3.11	Certificate Recognition OT	272
6.1.3.12	Course Recognition OT.....	272
6.1.3.13	Length of Certificate Validity OT	272

6.2	Lifeguard Training.....	272
6.2.1	Lifeguard Qualifications.....	273
6.2.1.1	Course Content LG.....	274
6.2.1.1.1	Hazard Identification and Injury Prevention LG.....	274
6.2.1.1.2	Emergency Response Skill Set LG.....	274
6.2.1.1.3	CPR Skills LG.....	275
6.2.1.1.4	First Aid LG.....	275
6.2.1.1.5	Legal Issues LG.....	275
6.2.1.2	Lifeguard Training Delivery LG.....	275
6.2.1.2.1	Standardized and Categorized LG.....	275
6.2.1.2.2	Skills Practice LG.....	275
6.2.1.2.3	Shallow Water Training LG.....	276
6.2.1.2.4	Deep Water Training LG.....	276
6.2.1.2.5	Sufficient Time LG.....	276
6.2.1.2.6	Certified Instructors LG.....	276
6.2.1.2.7	Training Equipment LG.....	277
6.2.1.3	Competency and Certification LG.....	278
6.2.1.3.1	Proficiency LG.....	278
6.2.1.3.2	Requirements LG.....	278
6.2.1.3.3	Instructor Physically Present LG.....	278
6.2.1.3.4	Certifications LG.....	279
6.2.1.3.5	Number of Years LG.....	279
6.2.1.3.6	Documentation LG.....	279
6.2.1.3.7	Expired Certificate LG.....	280
6.2.2	Aquatic Supervisor Training.....	280
6.2.2.1	Lifeguard Supervisor Candidate Prerequisites LG.....	280
6.2.2.2	Lifeguard Supervisor Training Elements LG.....	280
6.2.2.3	Lifeguard Supervisor Training Delivery LG.....	281
6.2.2.3.1	Standardized and Comprehensive LG.....	281
6.2.2.3.2	Sufficient Time LG.....	281
6.2.2.3.3	Certified Instructors LG.....	281
6.2.2.4	Competency and Certification LG.....	282
6.2.2.4.1	Lifeguard Supervisor Proficiency LG.....	282
6.2.2.4.2	Lifeguard Supervisor Certifications LG.....	282
6.3	Facility Staffing.....	282
6.3.1	Operators Requirements and Availability.....	282
6.3.2	Facilities Requiring Lifeguards.....	282
6.3.3	Safety Plan.....	284
6.3.3.1	Code Compliance Staff Plan LG.....	285
6.3.3.1.1	Zone of Patron Surveillance LG.....	286
6.3.3.1.2	Rotation Procedures LG.....	287
6.3.3.2	Emergency Action Plan LG.....	288
6.3.3.2.1	Coordination of Response LG.....	289
6.3.3.3	Pre-Service Requirements LG.....	289
6.3.3.3.1	Safety Team EAP Training LG.....	289
6.3.3.3.2	Safety Team Skills Proficiency LG.....	289

6.3.3.3.3	Qualified Lifeguard EAP Training LG	289
6.3.3.3.4	Qualified Lifeguard Skills Proficiency LG.....	290
6.3.3.3.5	CPR/AED and First Aid Certificate LG	290
6.3.3.3.6	Documentation of Pre-Service Training LG.....	290
6.3.3.4	In-Service Training LG	290
6.3.3.4.1	Documentation of In-Service Training LG.....	290
6.3.3.4.2	In-Service Documentation LG.....	291
6.3.3.4.3	In-Service Training Plan LG.....	291
6.3.3.5	AHJ Authority to Approve Safety Plan LG	292
6.3.3.5.1	Safety Plan on File LG.....	292
6.3.3.5.2	Subject for Implemented LG	292
6.3.4	Staff Management.....	292
6.3.4.3	Lifeguard Staff	292
6.3.4.3.1	Minimum Number of Lifeguards LG	292
6.3.4.3.2	Lifeguard Responsibilities LG.....	292
6.3.4.3.3	Shallow Water Certified Lifeguards LG.....	293
6.3.4.3.4	Direct Surveillance LG	293
6.3.4.3.5	Distractions LG.....	293
6.3.4.4	Supervisor Staff LG	293
6.3.4.4.1	Lifeguard Supervisor Required LG	293
6.3.4.4.2	Designated Supervisor LG.....	294
6.3.4.5	Emergency Response and Communications Plans RM	294
6.3.4.5.1	Emergency Response and Communication Plan RM	294
6.3.4.5.5	Training Documentation RM.....	294
6.3.4.5.8	Communication Plan RM	294
6.3.4.5.9	Inclement Weather Plan RM.....	294
6.3.4.6	Remote Monitoring Systems RM.....	295
6.3.4.6.1	Lifeguard-Based RM	295
6.3.4.6.2	Operator-Based RM.....	295
6.3.4.7	Employee Illness and Injury Policy RM	296
6.3.4.7.2	Open Wounds RM	296
6.4	Facility Management	296
6.4.1	Operations	298
6.4.1.1	Operations Manual FMO	298
6.4.1.1.1	Develop FMO	298
6.4.1.1.2	Include FMO.....	298
6.4.1.2	Preventive Maintenance and System Check Program and Recordkeeping.....	301
6.4.1.2.3	Illness and Injury Reports REG.....	301
6.4.1.2.5	Daily Water Monitoring and Testing Records FMO	302
6.4.1.2.8	Body Fluids Remediation Log FMO	303
6.4.2	Patron-Related Management Aspects.....	305
6.4.2.1	Bather Load RM.....	305
6.4.2.2	Signage RM.....	305
6.4.2.2.4	Sign Messages RM	305
6.4.2.2.6	Spa Venue Signs RM.....	305
6.4.2.2.8	Diaper-Changing Station Signage HYG.....	306

6.4.2.3	User Guidelines RM.....	306
6.4.2.4	Swimmer Empowerment Methods.....	306
6.4.2.4.1	Public Information and Health Messaging VEN	306
6.4.2.4.2	Post Inspection Score REG.....	306
6.4.2.4.3	Certificates Retained REG.....	307
6.5	Fecal/Vomit/Blood Contamination Response	307
6.5.1	Contamination Response Plan FVB.....	308
6.5.1.2.1	Minimum FVB.....	308
6.5.2	Water Contamination Response.....	309
6.5.2.2.2	No Vacuum Cleaners FVB	309
6.5.2.3	Treated FVB.....	309
6.5.3	Pool Water Contamination Disinfection.....	309
6.5.3.1	Formed-Stool Contamination FVB	309
6.5.3.1.1	Pools Containing Chlorine Stabilizers	310
6.5.3.2	Diarrheal-Stool Contamination FVB	310
6.5.3.2.1	Pools Containing Chlorine Stabilizers FVB	311
6.5.3.3	Vomit-Contamination FVB.....	311
6.5.3.4	Blood-Contamination FVB	312
6.5.3.5	Procedures for Brominated Pools FVB.....	312
6.5.4	Surface Contamination Cleaning and Disinfection.....	312
6.5.4.1	Limit Access FVB.....	312
6.5.4.2	Clean Surface FVB.....	313
6.5.4.3	Disposal FVB	313
6.5.4.4	Disinfect Surface FVB	313
6.6	AHJ Inspections.....	313
6.6.1	Inspection Process.....	313
6.6.1.1	Inspection Authority REG.....	313
6.6.2	Publication of Inspection Forms	313
6.6.3	Forms REG	313
6.6.4	Imminent Health Hazard Violations	313
6.6.4.1	Violations REG	313
6.6.5	Enforcement.....	315
6.6.6	Enforcement Penalties	315
6.6.7	Public Nuisance	315
6.6.8	Fees	315
MAHC Resources.....		316
	Preface & User Guide Resources	316
	Operator Training Resources.....	316
	Hygiene Facilities Resources.....	318
	Fecal-Vomit-Blood Resources	319
	Monitoring and Testing Resources.....	320
	Risk Management Resources.....	323

References Cited in Module:	324
Design and Construction Resources	325
Regulatory Resources	329
Disinfection and Water Quality Resources	330
Contamination Burden Resources	336
Lifeguard Resources	340
Recirculation & Filtration Bibliography.....	344
Ventilation Resources.....	348
Codes Referenced	348
References.....	348
Appendices	353
Appendix 1: Summary of Health and Exposure Data for Chemical and Biological Contaminants	353
Appendix 2: Air Quality Formula	357
Appendix 3: Dye Test Procedure.....	364
Materials	364
Procedure	364

Information to Assist the User with the MAHC Format

Organization

The *Model Aquatic Health Code* is divided into chapters and subsections that focus on each operational area (Design and Construction, Operation and Maintenance, Policies and Management) important to safeguarding public health at aquatic facilities.

Section Number

The international numbering system is used to organize the guidelines in this document.

Title, Keyword, Phrase

Each of the guidelines is formatted with a title, keyword, or phrase after the section number.

Description

Wording guidance or explanation is provided in this statement

Module Abbreviations

To bridge continuity from module to fully merged code, the MAHC committee decided to add abbreviations from the previous module format beside most sections. These abbreviations will not be in the final MAHC publication. The abbreviations are as follows:

- REG Regulatory
- D&C Design & Construction
- RM Risk Management
- VEN Ventilation
- LG Lifeguard & Bather Supervision
- R&F Recirculation & Filtration
- DWQ Disinfection & Water Quality
- M&T Monitoring & Testing
- HYG Hygiene
- FMO Facility Maintenance & Operation
- OT Operator Training
- FVB Fecal Vomit Blood Contamination
- CB Contamination Burden

1.0 Preface

1.1 Introduction

1.1.1 Rationale

With hundreds of millions of visits¹ to AQUATIC FACILITIES, waterparks, and natural recreational water sites each year, BATHERS expose themselves to many potential dangers in and around AQUATIC FACILITIES. Drowning and falling, diving, chemical use, and suction injuries continue to be major public health injuries associated with AQUATIC FACILITIES, particularly for young children.^{2,3,4,5} Thus, public health and SAFETY is essential to consider starting with the design and construction of public AQUATIC FACILITIES.

1.1.2 Need for Further Guidance

1.1.3 Responsibility of User

1.1.4 Original Manufacturer Intent

1.1.5 Local Jurisdiction

1.2 Recreational Water-Associated Illness (RWI) Outbreaks and Injuries

1.2.1 RWI Outbreaks

Since 1978, the number of recreational water-associated WATERBORNE DISEASE outbreaks (WBDOs) reported annually has increased dramatically.⁶ This increase is probably due to a combination of factors including:

- The emergence of PATHOGENS, especially CHLORINE-tolerant *Cryptosporidium*,
- Increased participation in aquatic activities, and
- Increases in the number of AQUATIC FACILITIES,
- Increased recognition, investigation, and reporting of outbreaks that may have previously gone undetected.

¹ US Census Bureau. Statistical Abstract of the United States: 2012. Arts, Recreation, and Travel: Participation in Selected Sports Activities 2009. . Available at <http://www.census.gov/compendia/statab/2012/tables/12s1249.pdf>. Accessed March 16, 2014.

² CDC. Drowning – United States, 2005-2009. MMWR Morb Mortal Wkly Rep. 2012;61(19):344-347.

³ CDC. Ten leading causes of injury deaths by age group highlighting unintentional injury deaths, United States – 2010

⁴ CDC. Pool chemical-associated health events in public and residential settings — United States, 1983–2007. MMWR Morb Mortal Wkly Rep. 2009;58(18):489-93.

⁵ CDC. Acute illness and injury from swimming pool disinfectants and other chemicals — United States, 2002-2008. MMWR Morb Mortal Wkly Rep. 2011;60(39):1343-1347.

⁶ Hlavsa MC et al. Recreational water-associated disease outbreaks — United States, 2009–2010. Morb Mortal Wkly Rep. 2014;63(1):6-10.

Over 2009-2010, a total of 81 recreational water-associated WBDOs and 1,366 cases or illness and 62 hospitalizations were reported to the CDC. CDC documented that 57 of these outbreaks and 78% of the cases were associated with disinfected water venues.⁷

Multiple challenges exist for providing adequate cleaning and disinfecting of swimming water. Sunlight, urine, exposure to air, and inorganic and organic matter (i.e. sweat, saliva, feces) can quickly deplete FREE AVAILABLE CHLORINE, the primary disinfectant used in POOLS. AQUATIC FACILITIES also provide potential exposure to FECAL contamination from other swimmers. These incidents are common in AQUATIC FACILITIES, especially from diaper-aged BATHERS who are not toilet trained (babies and toddlers).

1.2.2 Significance of *Cryptosporidium*

One such pathogen is *Cryptosporidium* (FECAL-ORALLY transmitted), which can survive for days in chlorinated swimming POOLS because it is extremely CHLORINE resistant.^{8,9,10} *Cryptosporidium* and other waterborne pathogens have a low infectious dose and can still be excreted from the body weeks after diarrhea ends. These factors increase the potential for a WATERBORNE DISEASE outbreak. WATERBORNE DISEASES and outbreaks can include the following:

- Gastrointestinal illness resulting from exposure to pathogens such as *Escherichia coli* O157:H7 or *Cryptosporidium*,
- Infections of the brain, skin, ear, eye, and lungs,
- Wounds, and
- Exposure to chemicals.

There were 21 treated recreational water-associated outbreaks reported in 2009-2010 that were caused by *Cryptosporidium*, a substantial increase from the 8 reported for treated AQUATIC FACILITIES in 1997-1998.^{11,12} In addition, during 1999-2008 *Cryptosporidium* was identified as the cause of 74.4% of gastroenteritis outbreaks at disinfected AQUATIC FACILITIES.¹³

⁷ Hlavsa MC et al. Recreational water-associated disease outbreaks — United States, 2009–2010. *Morb Mortal Wkly Rep.* 2014;63(1):6-10.

⁸ Korich DG, et al. Effects of ozone, chlorine dioxide, chlorine, and monochloramine on *Cryptosporidium parvum* oocyst viability. *Appl Environ Microbiol* 1990;56:1423-1428.

⁹ Shields JM, et al.. Inactivation of *Cryptosporidium parvum* under chlorinated recreational water conditions. *J Water Health* 2008;6:513-520.

¹⁰ Shields JM, et al. The effect of cyanuric acid on the chlorine inactivation of *Cryptosporidium parvum*. *J Water Health* 2009;7:109-114.

¹¹ Hlavsa MC, Roberts VA, Kahler AM, Hilborn ED, Wade TJ, Backer LC, Yoder JS. MMWR Recreational water-associated disease outbreaks — United States, 2009–2010. *Morb Mortal Wkly Rep.* 2014;63(1):6-10.

¹² Barwick RS, et al.. Surveillance for waterborne-disease outbreaks, United States, 1997-1998. *MMWR Surveill Summ*, 2000;49 (4):1-35.

¹³ Hlavsa MC, Roberts VA, Kahler AM, Hilborn ED, Wade TJ, Backer LC, Yoder JS. MMWR Recreational water-associated disease outbreaks — United States, 2009–2010. *Morb Mortal Wkly Rep.* 2014;63(1):6-10.

1.2.3 Drowning and Injuries

Drowning and falling, diving, chemical use, and suction injuries continue to be major public health injuries associated with AQUATIC FACILITIES. Drowning is a leading cause of injury death for young children ages 1 to 4, and the fifth leading cause of unintentional injury death for people of all ages.¹⁴ From 2008 through 2010, an average of 5,100 POOL- or SPA-related emergency department (ED)-treated submersion injuries occurred each year. For 2006-2008, 383 POOL- or SPA-related fatalities involved children younger than 15 years of age. Approximately 45% of the estimated injuries for 2008 through 2010 and 28% of the fatalities for 2006 through 2008 involving children younger than 15 occurred in a public setting.¹⁵

1.2.4 Pool Chemical-Related Injuries

For 2007-2008, 32 POOL chemical--associated health events that occurred in a public or residential setting were reported to CDC by Maryland and Michigan. These events resulted in 48 cases of illness or injury; 26 (81.3%) events could be attributed at least partially to chemical handling errors (e.g., mixing incompatible chemicals). ATSDR's Hazardous Substance Emergency Events Surveillance System received 92 reports of hazardous substance events that occurred at AQUATIC FACILITIES. More than half of these events (55 [59.8%]) involved injured persons; the most frequently reported primary contributing factor was human error. Estimates based on CPSC's National Electronic Injury Surveillance System (NEISS) data indicate that 4,574 (95% confidence interval [CI]: 2,703--6,446) emergency department (ED) visits attributable to POOL chemical--associated injuries occurred in 2008; the most frequent diagnosis was poisoning (1,784 ED visits [95% CI: 585--2,984]).¹⁶

1.3 Model Aquatic Health Code (MAHC)

1.3.1 Background

This effort stems from a CDC-sponsored workshop titled "Recreational Water Illness Prevention at Disinfected Swimming Venues" convened on February 15-17, 2005, in Atlanta, Georgia in response to a position statement from the Council of State and Territorial Epidemiologists asking for CDC to convene such a meeting. The workshop assembled contributors from different disciplines working in state, local, and federal public health agencies and the aquatics industry to discuss ways to minimize recreational water illnesses spread through disinfected AQUATIC VENUES. CDC has been working with public health and industry representatives across the United States to build this effort since 2007. Initial efforts have been focused on reducing the spread of recreational water illnesses and prevention of injuries at treated public swimming venues.

¹⁴ CDC. [Drowning – United States, 2005-2009](#). MMWR Morb Mortal Wkly Rep. 2012;61(19):344-347.

¹⁵ Gipson K. Pool or Spa Submersion: Estimated Injuries and Reported Fatalities, 2011 Report. U.S. Consumer Product Safety Commission, May 2011. Available online at <http://www.cpsc.gov/LIBRARY/FOIA/FOIA11/os/pools2011.pdf>.

¹⁶ Hlavsa MC, et al. Surveillance for waterborne disease outbreaks and other health events associated with recreational water use — United States, 2007–2008. MMWR Surveill Summ 2011;60:1-37.

1.3.2 MAHC Vision and Mission**1.3.3 Best Available Practice****1.3.4 Process****1.3.5 Updating the MAHC****1.3.6 Authority****1.3.7 CDC Role****1.3.7.1 Public Health Role****1.3.7.2 Model Guidance****1.4 Public Health and Consumer Expectations****1.4.1 Industry & Government Responsibility****1.4.2 Swimmer Responsibility****1.5 Advantages of Uniform Guidance****1.5.1 Industry Agreement**

Industry and government officials have long recognized the advantages of well-written, scientifically sound, and up-to-date model guidance. Industry acceptance of procedures and practices is far more likely where regulatory officials "speak with one voice" about

- what is required to protect the public health,
- why it is important, and
- which alternatives for compliance may be accepted.

Model guidance provides

- A guide for use in establishing what is required,
- Businesses with accepted guidance STANDARDS that can be applied to training and quality assurance programs, and
- Local, state, and federal governmental bodies help with developing or updating their own CODES.

1.5.2 MAHC Provisions

1.5.3 Aquatic Facility Requirements

1.6 Modification and Improvements in this MAHC Version

1.7 MAHC Adoption at State or Local Level

1.7.1 MAHC Adoption at State or Local Level

The MAHC is provided for use by governing bodies at all levels to regulate AQUATIC FACILITIES . At the state and local levels the MAHC may be used in part or in whole to:

- Enact into statute as an act of the state legislative body;
- Promulgate as a regulation; or
- Adopt as an ordinance.

Typically, CODE adoption bodies (federal, state, and local governments) publish a notice of their intent to adopt a CODE, make copies available for public inspection, and provide an opportunity for public input prior to adoption. As is also outlined in the FDA Model Food Code, this is usually done in one of two ways.

The recommended method is the "short form" or "adoption by reference" approach where a simple statement is published stating that certified copies of the proposed CODE are on file for public review. This approach may be used by governmental bodies located in states that have enabling laws authorizing the adoption of CODES by reference. An advantage to this approach is a substantial reduction in the cost of publishing and printing. The alternative method is the "long form" or "section-by-section" approach where the proposed CODE is published in its entirety. Both methods of adoption allow for the modification of specific provisions to accommodate existing law, administrative procedure, or regulatory policy.

1.8 The MAHC Revision Process

1.8.1 MAHC Revisions

CDC will accept concerns and recommendations for modification of the MAHC from any individual or organization through two 60-day public comment periods via the email address MAHC@cdc.gov. See the website at <http://www.cdc.gov/healthywater/swimming/POOLS/mahc/index.html> for more information.

1.8.2 Future Revisions

Given the vision, mission, and goals of the MAHC as discussed in item Section 1.3 of this Preface, the MAHC governing body will be especially interested in addressing any problems identified. CDC will also be especially responsive to those needed policy and technical changes raised by the general public or an organization that uses a

democratic process for addressing problems and concerns. Included are organizations that provide a process that encourages representative participation in deliberations by government, industry, academic, and consumer interests, followed by public health ratification such as a state-by-state vote by officially designated delegates.

These organizations receive problems submitted by any interested individual, but specify the forms on which the issues must be detailed and provide specific time frames during which they may be submitted. CDC encourages interested individuals to consider raising issues and suggesting solutions involving the federal-state cooperative programs based on the MAHC through these organizations.

The MAHC will likely follow an update process similar to that of the Conference for Food Protection. This allows all interested partners to put in position papers to modify the MAHC and have a vote on modification.

1.9 Acknowledgements

1.9.1 Diversity

1.9.2 Dedication

1.9.3 Development

2.0 User Guide

2.1 Overview

2.1.1 New Users

2.1.2 Topic Presentations

2.2 MAHC Structure and Format

The MAHC utilizes the format also found in the FDA Model Food Code; thus within the MAHC, references are made to the FDA Model Food Code and the Conference for Food Protection. These are purely for reference and to gain a better scope of perspective and protocol.

2.2.1 Numbering System

2.2.2 Title, Keyword, or Phrase Text

2.2.3 MAHC Requirement

2.2.4 Illustrations

2.2.5 Consistency Between Chapters 4.0 and 5.0

2.2.6 Conventions

2.2.7 Definitions

2.3 Annex

2.3.1 Rationale

The annex is provided as a supplement to the code; thus, the annex is not intended to be interpreted or enforced as model code. This is necessary in order to keep future laws or other requirements based on the MAHC straightforward. However, the annex is provided specifically to assist users in understanding and applying the provisions uniformly and effectively.

2.3.2 Content

To use the MAHC more effectively, users should preview the annex contents before using parts of the MAHC model code language. The annex is structured to present the information by the specific MAHC section number to which they apply. The Annex and Appendices also provide information and materials intended to be helpful to the user such as forms, recreational water illness outbreak response guidance, and guidelines for facility inspection.

2.3.3 Bibliography**2.3.4 Appendices**

3.0 Glossary of Acronyms and Terms Used in the MAHC

Acronyms Used in the MAHC:

See the Model Aquatic Health Code, Code Section

Glossary Terms Used in the MAHC:

See the Model Aquatic Health Code, Code Section

4.0 Design and Construction

4.0.1 Basic Design Considerations for Handling Particle Contamination Burden, Chlorine and Disinfectant Demand, and Disinfection By-Product Issues

4.0.1.1 Particle Contamination Burden

4.0.1.1.1

The particle contamination burden determines the filtration flow rate for a given AQUATIC FACILITY. It is not possible to predict the particle contamination burden for every individual POOL because the sources will likely vary significantly from one AQUATIC FACILITY to another. However, it is important to understand the upper limit of particle contamination to provide information for filtration designs. If the upper limit of the particle contamination burden is known, then it should be possible for the designer to specify a filtration system that can handle the maximum particle burden and ensure that water turbidity does not increase above an allowable or desirable level. Essentially, the RECIRCULATION SYSTEM needs to be designed to remove particles at least at the same rate at which they are being added by the environment (e.g., windblown and settling dust), PATRONS (e.g., personal care products, body excretions), and other sources.

4.0.1.1.2

The best means for determining this maximum rate of particle contamination is through direct measurement at operating facilities to ensure the data are indicative of normal activity. The rate of contamination (n, particles/time/gallon) is likely to vary by POOL location, BATHER LOADING, BATHER age, time of year, time of day, weather, and proximity to urban and desert environments.

4.0.1.1.3

An extensive literature search turned up no relevant data defining the particulate contamination burden in AQUATIC FACILITIES. It is recommended that a model be developed that describes particle addition and subsequent removal by the filtration system. This would include developing a correlation between particle size and turbidity or clarity index; this correlation is needed from a practical point of view since regulations are likely to be developed based on turbidity or clarity. These data could then be used for making concrete, data-based decisions on removal rate requirements and help with defining the required filtration and circulation capacities.

4.0.1.2 Disinfectant Demand

4.0.1.2.1

Disinfectant consumption can occur by the reaction of the disinfectant with BATHERS, BATHER waste, and other environmentally-introduced CONTAMINANTS, as well as simple decomposition of the active halides (i.e., hypochlorous acid, HOCl or hypobromous acid, HOBr) into inactive halide ions (chloride or bromide). Disinfectant decomposition

rates will also vary depending on a variety of factors including pH, water temperature, ultraviolet light, and BATHER LOAD. Data on disinfectant demand are generally lacking in the literature on all EPA-registered disinfectants. There are some data available for CHLORINE disinfectant demand, but there are very few for bromine, PHMB, and metal systems.

4.0.1.3 Chlorine Disinfectant Demand

4.0.1.3.1

Several studies have investigated BATHER LOAD contribution to CHLORINE demand in POOL water; however, there is a lack of consistency in how BATHER LOAD was measured. Some studies report data as CHLORINE demand, others as potassium permanganate demand, dissolved organic carbon or total organic carbon.^{17, 18, 19, 20}

4.0.1.3.2

The available data for CHLORINE disinfectant demand indicates that that the CHLORINE demand from BATHERS can vary by over an order of magnitude, with the largest value measured being 10 g Cl₂/BATHER (or 2.2 lb/100 BATHERS).²¹

4.0.1.3.3

There are few published data on the CHLORINE demand that occurs in POOLS due to the simple decomposition of CHLORINE. It is well known that CHLORINE is not stable at high temperatures and in the presence of UV. Both of these factors will reduce active CHLORINE to inactive chloride, without any BATHER waste being present.

4.0.1.3.4

The rate of CHLORINE loss (pounds of CHLORINE per hour) due to UV degradation will depend on a number of factors, including the size of the POOL, the depth of the water and the intensity of the sunshine. It will also depend on the concentration of cyanuric acid present, since cyanuric acid can help prevent the decomposition of CHLORINE by UV. Given the number of variables, it is difficult to predict CHLORINE decomposition rates in specific POOLS.

4.0.1.3.5

The rate of CHLORINE loss can be reduced by the use of other oxidizers, including potassium monopersulfate and ozone, or UV, which can destroy CONTAMINANTS which would otherwise react with CHLORINE. Additional research on the contributing factors to

¹⁷ Judd SJ, Black SH. Disinfection by-product formation in swimming pool waters: a simple mass balance. *Water Research* (2000); 34(5):1611-1619.

¹⁸ Judd SJ, Bullock G. The fate of chlorine and organic materials in swimming pools, *Chemosphere* (2003); 51:869-879.

¹⁹ Keuten MGA, et al. Definition and quantification of initial anthropogenic pollutant release in swimming pools. *Water Res.* 2012;46:3682-3692.

²⁰ Seux R. The development of pollution caused by swimmers in swimming pool water in relation to the effect of free chlorine. Translation from *Journal Francais d'Hydrologie* (1988);19(2):151-168.

²¹ Seux R. The development of pollution caused by swimmers in swimming pool water in relation to the effect of free chlorine. Translation from *Journal Francais d'Hydrologie* (1988);19(2):151-168.

disinfectant demand (i.e. nitrogenous waste) may be warranted in the future as treatment methods are developed to reduce or eliminate them by means other than OXIDATION. It is anticipated that this research would identify the introduction rate of the CONTAMINANT, resulting concentrations, and the effect that reduction or elimination of this CONTAMINANT would have on disinfectant demand or other ancillary benefits (i.e. reduction of combined CHLORINES).

4.0.1.3.6

Further data collection on CHLORINE usage in real world POOL situations under different environmental and operational conditions could be used to develop an effective rate law from which the sizing of chemical feed pumps could then be calculated.^{22, 23} The criteria for specifying a chemical feed pump for a swimming POOL are based on its ability to feed against the process piping pressure and to provide sufficient feed rate to maintain a disinfectant residual in the water. Several states require chemical feed pumps for CHLORINE to be capable of providing up to 10 ppm of CHLORINE in the pipe returning water from the RECIRCULATION SYSTEM back to the POOL. Once actual CHLORINE usage is obtained, a surplus SAFETY factor could be introduced to slightly oversize the feed pump to ensure that the disinfectant dosing amount can be increased to meet increases in demand. Any such sizing requirements need to specify the timeframe within which the pump must be able to satisfy the CHLORINE dosing required.

4.0.1.4 Disinfection By-product Issues

4.0.1.4.1

Chlorination, using CHLORINE as the disinfectant, is the most common procedure for swimming POOL water DISINFECTION and inactivation of waterborne microbial pathogens. Swimmers' activity and environmentally-introduced material provides a broad range of precursors with which disinfectants can react (e.g., perspiration, urine, mucus, skin particles, hair, body lotions, fecal material, soil, etc.). When CHLORINE reacts with these precursors, a variety of chemical reactions take place, including the formation of DISINFECTION BY-PRODUCTS (DBPs)^{24,25,26,27,28}. DBPs may also be introduced into the POOL via the water used to fill the POOL depending on the supply water quality. Municipal fill water can also include chloramines as some municipal systems switch from

²² March JG, et al. A kinetic model for chlorine consumption in grey water. *Desalination* (2005); 181:267-273.

²³ Haas CN, Karra SB. Kinetics of wastewater chlorine demand exertion. *J Water Pollution Control Federation*. 1984;56:170-3.

²⁴ Richardson SD, et al. What's in the pool? A comprehensive identification of disinfection by-products and assessment of mutagenicity of chlorinated and brominated swimming pool water. *Environmental Health Perspectives*. 2010 Nov;118(11):1523-30.

²⁵ LaKind JS, et al. The good, the bad, and the volatile: can we have both healthy pools and healthy people? *Environ Sci Technol*. 2010;44(9):3205-10.

²⁶ Zwiener C, et al. Drowning in disinfection byproducts/ assessing swimming pool water. *Environ. Sci. Technol*. (2007); 41(2):363–372.

²⁷ EPA. Drinking Water Contaminants. Available at: <http://water.epa.gov/drink/contaminants/index.cfm>. Accessed on: 03/23/2014.

²⁸ Praus P. Drinking water disinfection and formation of by-products. *Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava* (2003); 49(2): 95-102.

chlorination to chloramination to meet EPA DISINFECTION byproduct requirements.²⁹ CHLORINE gas, if used, is also extremely toxic.^{30,31,32}

4.0.1.4.2

DBPs can be organic^{33,34} [e.g., TRIHALOMETHANES, chlorinated phenols, haloketones, haloacetic acids, and haloacetonitriles (HANs)] or inorganic^{35,36,37} (e.g. chloramines and cyanogen chloride). The major by-products of DISINFECTION using hypobromous acid (HOBr) and hypochlorous acid (HOCl) are bromoform (CHBr₃) and chloroform (CHCl₃), respectively. Chloroform and bromoform are highly volatile compounds that can be inhaled in swimming POOL environments and also readily absorbed through the skin.^{38,39,40}

4.0.1.4.3

Some classes of organic DBPs⁴¹ are:

- TRIHALOMETHANES (total TRIHALOMETHANE is the sum of the concentrations of chloroform, bromoform, bromodichloromethane, and dibromochloromethane),
- chlorinated phenols (*2-chloro-*, *2,4-dichloro-* and *2,4,6-trichlorophenol*),
- haloketones (*1,1-dichloropropanone*, *1,1,1-trichloropropanone*),
- haloketones (bromopropanone, 1,1-dichloropropanone, 1,1,1-trichloropropanone, etc.)
- haloacetic acids (Total haloacetic acids include the sum of the concentrations of mono-, di-, and trichloroacetic acids and mono- and dibromoacetic acids);
- haloacetonitriles (HANs) include (dichloro-, trichloro-, dibromo- and bromochloroacetonitrile), chloropicrin, chloral hydrate, 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone, etc.

²⁹ EPA. Drinking Water Contaminants. Available at: <http://water.epa.gov/drink/contaminants/index.cfm>. Accessed on: 03/23/2014.

³⁰ ATSDR. Toxicological Profile for Chlorine. (2010) Available at: <http://www.atsdr.cdc.gov/facts172.pdf>. Accessed on: 03/23/2014.

³¹ Decker WJ, Koch HF. Chlorine poisoning at the swimming pool: an overlooked hazard. *Clinical Toxicology* (1978); 13(3): 377-381.

³² Drobnic F, et al. Assessment of chlorine exposure in swimmers during training. *Medicine and Science in Sports and Exercise* (1996); 28(2): 271-274.

³³ Richardson SD, et al. What's in the pool? A comprehensive identification of disinfection by-products and assessment of mutagenicity of chlorinated and brominated swimming pool water. *Environmental Health Perspectives*. 2010 Nov;118(11):1523-30.

³⁴ Weng AS, Li J, Blatchley III E. Effects of UV254 irradiation on residual chlorine and DBPs in chlorination of model organic-N precursors in swimming pools. *Water Res.* 2012;46:2674-268.

³⁵ Erdinger L, et al. Chlorate as an inorganic disinfection by product in swimming pools. *Zentralbl Hyg Umweltmed* (1999); 202: 61-75.

³⁶ Beech JA, et al. Nitrates, chlorates and trihalomethanes in swimming pool water. *American Journal of Public Health* (1980); 70(1): 79-82.

³⁷ Robson HL. Chloramines and bromamines; *Encyclopedia of Chemical Technology*, Kirk-Othmer, 4d ed, Interscience, New York.

³⁸ Aggazzotti G, et al. Blood and breath analyses as biological indicators of exposure to trihalomethanes in indoor swimming pools. *Science of the Total Environment* (1998); 217: 155-163.

³⁹ Erdinger L, et al. Haloforms in spas. *Zentralbl Hyg Umweltmed* (1997);200: 309-317.

⁴⁰ Hanna JG, Siggia S. Determination of chloroform and bromoform. *Anal Chemistry*(1950);22(4):569-570.

⁴¹ Erdinger L, et al. Chlorate as an inorganic disinfection by product in swimming pools. *Zentralbl Hyg Umweltmed* (1999); 202: 61-75.

- Organic Chloramines

4.0.1.4.4

According to European Union regulations, the concentration of TRIHALOMETHANES in drinking water should not exceed one hundred micrograms per liter (100 µg/L) of water for consumption⁴²; while in the United States the Environmental Protection Agency (US-EPA) has established a legal maximum of 80 µg/L⁴³. The DIN 19643 swimming POOL STANDARD specifies a STANDARD maximum of 20 µg/L.⁴⁴

4.0.1.4.5

Inorganic DBPs include chloramines and cyanogen chloride. Inorganic chloramines include monochloramine (NH₂Cl), DICHLORAMINE (NHCl₂) and TRICHLORAMINE (NCl₃) and are generated from the reaction of hypochlorite with ammonia and amino-compounds that originate from sweat and urine of the swimmers. TRICHLORAMINE is relatively volatile and partitions easily from water into air.⁴⁵

4.0.1.4.6

The conditions that determine production and air levels of DBPs have been suggested to depend on several factors:

- Number of swimmers in the POOL, and their associated hygiene
- CHLORINE concentration,
- water temperature
- concentration of organic precursors in the POOL water,
- chemical structure of the organic precursors,
- bromide content,
- indoor air circulation,
- the extent of out-gassing of volatile DBPs,
- pH,
- level of water agitation (undisturbed vs. being sprayed), and
- concentration of inorganic chloramine from the fill water.

Further research is needed to determine how much DBPs are being created in POOL water, including the production and retention rate.

4.0.1.4.7

Studies have examined the link between air quality in INDOOR AQUATIC FACILITIES and respiratory effects, including asthma. If there is poor ventilation in the building or AQUATIC VENUE area, it could be the cause of negative health effects for BATHERS from

⁴² Council Directive 98/83/EC on the Quality of Water Intended for Human Consumption, 1998 O.J. L 330/32.

⁴³ EPA. Drinking Water Contaminants. Available at: <http://water.epa.gov/drink/contaminants/index.cfm>. Accessed on: 03/23/2014.

⁴⁴ German Standard DIN 19643, 2012. Treatment of Water of Swimming-Pools and Baths..Deutsches Institut Fur Normung E.V. (German National Standard).

⁴⁵ Holzwarth G, et al. The fate of chlorine and chloramines in cooling towers. Water Res. 1984;18:1421–1427.

inhalation exposure to the chloramines^{46,47,48}. To date, however, research results on the link to asthma are mixed and inconclusive^{49,50,51,52}. The one prospective study available⁵³ suggests swimming does not increase the risk of asthma. To the contrary, the study found swimming increased lung function and reduced the risk of asthma symptoms at age seven. The health benefits associated with swimming include improvement of asthma symptoms and cardiovascular fitness. Pediatricians have long recommended swimming for asthmatic children because of its lower asthmogenicity compared to other forms of exercise. The Belgian Superior Health Council⁵⁴ reviewed the available science related to POOL swimming and the development of childhood asthma. The Council, in its 2011 report No. 8748 (and reiterated in its 2012 report) concludes swimming remains highly advisable, even in the case of asthma. According to the Council, “For this target group, the advantages of swimming under good hygienic conditions in monitored POOLS outweigh the risk of toxicity linked to CHLORINE and its by-products.”^{55,56,57,58,59}

4.0.1.4.8

Despite the health risks of DISINFECTION BY-PRODUCTS (DBPs) in general, the concentration of organic DBPs found in POOLS is generally low. Therefore, although research results have shown that DBPs do form in detectable concentrations in most POOLS^{60, 61, 62} and levels of exposure can be measured^{63,64}, it appears that the benefits of

⁴⁶ Yoder JS, et al. Surveillance for waterborne disease outbreaks associated with recreational water – US, 2001-2002. *MMWR Surveill Summ* 53, 1-22.

⁴⁷ Mustchin CP, Pickering CA. Coughing water: bronchial hyper-reactivity induced by swimming in a chlorinated pool. *Thorax* (1979); 34(5): 682-683.

⁴⁸ Bowen AB, et al. Outbreaks of short-incubation ocular and respiratory illness following exposure to indoor swimming pools. *Environmental Health Perspectives* (2007); 115(2): 267-271.

⁴⁹ Williams A, et al. Increased concentration of chlorine in swimming pool water causes exercise-induced bronchoconstriction (EIB). *Medicine and Science in Sports and Exercise* (2004); 36(5) Supplement abstract 2046.

⁵⁰ Nemery B, et al. Indoor swimming pools, water chlorination, and respiratory health. *Eur. Respir. J.* (2002); 19: 790-793.

⁵¹ Nordberg GF, et al. Lung function in volunteers before and after exposure to trichloramine in indoor pool environments and asthma in a cohort of pool workers. *BMJ Open*. 2012 Oct 8;2(5).

⁵² Lagerkvist BJ, et al. Pulmonary epithelial integrity in children: relationship to ambient ozone exposure and swimming pool attendance. *Environ Health Perspect* (2004);112:1768-1771.

⁵³ Font-Ribera L, et al. Swimming pool attendance, asthma, allergies, and lung function in the Avon Longitudinal Study of Parents and Children cohort. *Am J Respir Crit Care Med.* (2011 Mar 1);183(5):582-8. doi: 10.1164/rccm.201005-0761OC.

⁵⁴ Belgian Superior Health Council. Publication no. 8748: The issue of chlorine in swimming pools: Risk attendant on baby swimming and reflections on the different methods used to disinfect swimming pools.

⁵⁵ Bernard A, et al. Lung hyperpermeability and asthma prevalence in schoolchildren: unexpected associations with the attendance at indoor chlorinated swimming pools. *Occupational and Environmental Medicine* (2003); 60: 385-394.

⁵⁶ Goodman M, Hays S. Asthma and swimming: A meta-analysis. *J of Asthma* (2008);45(8):639-647.

⁵⁷ Thickett KM, et al. Occupational asthma caused by chloramines in indoor swimming-pool air. *Eur. Respir. J.* (2002)19: 827-832.

⁵⁸ Weisel CP, et al. Childhood asthma and environmental exposures at swimming pools: State of the science and research recommendations. *Environmental Health Perspectives* (2009); 117: 500-507.

⁵⁹ LaKind JS, et al. The good, the bad, and the volatile: can we have both healthy pools and healthy people? *Environ Sci Technol.* 2010;44(9):3205-10.

⁶⁰ Kim H, et al. Formation of disinfection by-products in chlorinated swimming pool water. *Chemosphere* (2002); 46:123-130.

⁶¹ Bessonneau V, et al. Determinants of chlorination by-products in indoor swimming pools. *Int Hyg Environ Health.* 2011;215:76-85.

⁶² Weng S, Blatchley E. DBP dynamics in a chlorinated, indoor swimming pool under conditions of heavy use:

DISINFECTION far outweigh the risks posed by its by-products⁶⁵. The World Health Organization, states that “the risks from exposure to chlorination by-products in reasonably well-managed swimming POOLS would be considered to be small and must be set against the benefits of aerobic exercise and the risks of infectious disease in the absence of DISINFECTION.”⁶⁶ Improved water quality management is recommended to minimize formation and accumulation of these compounds.

4.0.1.4.9

A major CONTAMINANT in POOL water is urea. Urea is chiefly derived from swimmers urinating in POOL water, but is also present in swimmer’s sweat. It has been shown that urea reacts with hypochlorous acid to produce TRICHLORAMINE. However, while breakpoint destruction of ammonia is very fast, reaction of hypochlorous acid with urea is very slow. Therefore, urea is difficult to remove quickly by shocking the POOL water. There are no guidelines in the U.S. for MONITORING the urea concentration in POOL water or suggested levels of concern. Input of urea is most effectively minimized by changes in swimmers’ behavior and hygiene.^{67,68, 69,70,71}

4.1 Plan Submittal

4.1.1 Plan Submittal **REG**

4.1.2 Content of Design Report **REG**

4.1.2.1 Basis of Design Report **REG**

4.1.2.1.1 Names / Addresses **REG**

AQUATIC FACILITY plans should include a map indicating the exact location of the AQUATIC FACILITY with street address and geographic location information including the GPS coordinates.

National swimming competition. Water Res. 2011;45(16):5241-5248.

⁶³ Cammann K, Hubner K. Trihalomethane concentrations in swimmers' and bath attendants' blood and urine after swimming or working in indoor swimming pools. Archives of Environmental Health (1995); 50(1): 61-65.

⁶⁴ Lindstrom AB, et al. Alveolar breath sampling and analysis to assess trihalomethane exposures during competitive swimming training. Environmental Health Perspectives (1997); 105(6):636-642

⁶⁵ WHO (2000). Environmental Health Criteria 216 (including corrigenda from 11/30/2004).

http://whqlibdoc.who.int/ehc/WHO_EHC_216.pdf

⁶⁶ WHO (2006). Guidelines for safe recreational-water environments, Volume 2: Swimming pools, spas and similar recreational-water environments.

⁶⁷ Blatchley E, Cheng M. Reaction mechanism for chlorination of urea. Environ Sci Technol. 2010 Nov 15;44(22):8529-34. doi: 10.1021/es102423u. Epub 2010 Oct 21.

⁶⁸ De Laat J, et al. “Concentration levels of urea in swimming pool water and reactivity of chlorine with urea”, Water Research, 2011, 45(3) 1139-1146.

⁶⁹ Schmalz C, et al. “Trichloramine in swimming pools – Formation and mass transfer”, Water Research, 2011, 45(8) 2681-2690.

⁷⁰ Fuchs J. Chlorination of pool water: urea degradation rate. Chemiker Ztg. -Chem. Apparatur (1962);86(3): 76-82.

⁷¹ Gunkel K, Jessen HJ. The urea problem in swimming pools. Z. gesamte Hyg. (1988); 34(4):248-50.

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4.1.2.2 Plans and Specifications **REG**

4.1.2.3 Technical Specifications **REG**

4.1.2.3.1 Accompany Drawings **REG**

Appurtenances include diving platforms, diving boards, WATER SLIDES, and other AQUATIC FEATURES.

4.1.2.3.2 Technical Details **REG**

Detailed specifications are required to ensure that there is no misunderstanding, ambiguity, or omission between the design professional and the AHJ reviewer.

4.1.2.3.5.1 Bather Load Calculation

The rationale for the BATHER density numbers for specific AQUATIC VENUE types is as follows:

1. FLAT WATER
 - a. These AQUATIC VENUES generally are for swimming
 - b. The density was established at 20 ft² per person. This represents an average horizontal swimmer occupying a 5ft by 4ft area.
 - c. Assuming a person is swimming horizontally; a full body length is an average 5 ft with a 5 ft SPAN to equal 25 ft². There was a need to account for higher density in shallow areas where users waded vertically versus swim horizontally. The middle ground was decided to be 20 ft².
2. AGITATED WATER
 - a. These AQUATIC VENUES generally are for wading, splashing, and enjoyment of features without swimming
 - b. The density was established at 15 ft² per person. This represents an average vertical user occupying a 5ft by 3ft area. This also complies with the Illinois State POOL Code.
3. HOT WATER
 - a. These AQUATIC VENUES generally are for lounging such as hot tubs, warming POOLS, etc.
 - b. The density was established at 10 ft² per person. This represents an average user sitting in a 3ft by 3ft area.

4.1.3 Plan Approval **REG**

Review **REG**

The construction of public AQUATIC FACILITIES should not be undertaken without a thorough review and approval of the proposed construction plans by the AHJ. Construction costs for AQUATIC FACILITIES can be in the millions of dollars and very costly mistakes in design and equipment choices can occur if plans are not reviewed before construction. These mistakes could result in both public health hazards and additional remodeling costs.

Most of the states require that plans be submitted for review and approval by the regulatory authority before a public AQUATIC FACILITY can be constructed. Although there is considerable variation in the amount of information and detail required on the plans, most of the jurisdictions require at least a plot plan with sufficient detail to allow for a reasonable review of the proposed project.

The licensed professional engineer or architect should have at least one year of previous experience with public AQUATIC FACILITY design. Most states will allow any professional engineer or architect to design an AQUATIC FACILITY. However, since AQUATIC DESIGN technology is sufficiently complex, specific prior experience in AQUATIC FACILITY construction and design is strongly recommended. A minimum of one year of previous experience in AQUATIC FACILITY construction and design is recommended.

Any final approval of plans by the AHJ should be dependent on approval by all other appropriate agencies.

For example, the assumption of responsibility for reviewing plans for structural SAFETY and ensuring the AQUATIC FACILITY is designed to withstand anticipated loading, not only the POOL shell, but also in cases where the POOL may be located on an upper floor of a building or a rooftop is generally that of the local building department. If there is no local building code department or requirements, the design engineer or architect must assume responsibility. This may include requiring architect/engineer to certify structural stability of POOL shell during full and empty conditions.

4.1.3.1	New Construction	REG
4.1.3.1.2	Plan Review Training	REG
4.1.3.1.7	Plans Maintained	REG
4.1.3.2	Non-Substantial Alterations	REG
4.1.3.3	Replacements	REG
	Sample Form	REG

Most jurisdictions allow for replacements in-kind.

4.1.4	Certificate of Compliance	REG
4.1.4.4	Systems Commissioning	REG

“Commissioning” or “testing of BATHER SAFETY” means completing a test, evaluation, or demonstration that confirms that the AQUATIC FACILITY, AQUATIC VENUES, AQUATIC VENUE FEATURES, or other equipment in question does not compromise the SAFETY of the PATRONS.

4.1.5 Construction Permits REG

4.1.5.4 Permit Denial REG

4.2 Materials

4.2.1 Pools D&C

4.2.1.2.1 Darker Colors D&C

Darker colors or designs such as rock formations may be allowed by the AHJ.

4.2.1.2.3 Design Parameters D&C

There are multiple forms of acceptable finishes available including but not limited to: paint, marcite plaster finish, quartz plaster finish, aggregate plaster finish, vinyl or PVC liner / paneling systems, stainless steel, tile, etc. Each system shall have advantages and disadvantages associated with cost, durability, clean-ability, etc. These advantages and disadvantages are also subject to installation design issues (e.g. indoors/outdoors, above/below water level, environmental effects, freezing or temperature exposures, etc.).

4.2.1.4 Smooth Finish D&C

SKIMMER POOLS require a 6" (150 mm) to 12" (300 mm) high finish due to the varying height of water associated with in POOL surge capacity of SKIMMER POOL systems. Gutter or perimeter overflow systems require a minimum finish height of 2" (50 mm). If dark colors are utilized for the POOL finish, the POOL finish should not exceed a maximum height of 12" (300 mm) for contrasting purposes. Typical finishes include: tile, stainless steel, vinyl, fiberglass, etc.

4.2.1.5 Slip Resistant D&C

Water 3 feet (0.9 m) and less is considered shallow water and the majority of PATRONS are capable of walking on the POOL bottom at these depths, so a slip-resistant surface is required. At depths greater than 3 feet (0.9 m), most PATRONS are sufficiently buoyant making the coefficient of friction for the POOL floor surface less important. Slip resistant surfaces shall meet or exceed the minimum coefficient of friction (typically 0.8 for ramped surfaces and 0.6 for other wet surfaces; currently, ASTM STANDARD C1028 is under revision.) as set forth by the following groups:

- Americans with Disabilities Act (ADA)
- Occupational Safety and Health Administration (OSHA)
- "Slip resistant" is usually considered to mean having a static coefficient of friction of 0.6 or better for both wet and dry conditions.

4.2.2 Natatorium D&C

4.2.2.1 Interior Finish D&C

4.2.2.2 Condensation Prevention D&C

Special care should be used in the construction of air-pressure-supported buildings to prevent the movement of moisture into building surfaces, conduits, etc.

4.2.2.2.1 Cold Weather D&C

Paints suitable for use as vapor retarders usually have high solids, and must be carefully applied to achieve a rating of 0.4 perm for one coat. It is important to get very good coverage without gaps or thin spots. The paint supplier or manufacturer should be consulted for ratings and BEST PRACTICES.

4.2.2.2.2 Paint or Coating D&C

One U.S. perm equals 1.0 grain of moisture per square foot per hour per inch-of-mercury differential pressure. One U.S. perm equals 57 SI perm.

4.2.2.3 Mechanical Systems D&C

4.2.2.3.3 Natatorium Air Pressure D&C

Air-pressure-supported NATATORIUMS may require pressurization of adjoining or connected SPACES.

4.2.2.4 Natatorium Doors D&C

Door Freezing

Where exterior doors of a NATATORIUM may be exposed to temperatures below the freezing temperature of water, the frames should be constructed to minimize the risk of the door freezing closed.

Exception 1: Other doors should be acceptable, subject to approval by the AHJ, where heating systems are so arranged as to maintain such doors at least 5°F (2.8°C) above the freezing temperature of water.

The issue here is one of emergency exit. There is a large amount of water vapor available to freeze into the gap between doors, etc.

4.2.2.5 Natatorium Windows D&C

Windows are usually maintained above NATATORIUM-air dew point to prevent condensation and mold growth by heated supply air flowing over them. Heavy window frames on the interior side interfere with the proper flow of this heated air by the Coanda effect (a corollary of Bernoulli's principle). There are many ways to mechanically address window condensation issues. Air supply can be dumped on glazing from both above and below. Fin tube heaters have also been effectively employed along sills in many instances.

- See ASHRAE Handbook of Fundamentals⁷²

4.2.2.6 Natatorium Electrical Systems

D&C

4.3 Equipment Standards

4.3.1 General

D&C

4.3.1.1 Accredited Testing Facility

D&C

Acceptable STANDARDS for common RECIRCULATION SYSTEM components are listed below:

- INLETS – NSF/ANSI
- Overflow System/Gutters – NSF/ANSI
- SKIMMERS – NSF/ANSI
- Valves – NSF/ANSI
- Piping and Face Piping – NSF/ANSI
- Fittings – NSF/ANSI
- Strainers – NSF/ANSI
- Gauges – NSF/ANSI
- Flow Meters – NSF/ANSI
- Solar POOL Heaters – NSF/ANSI
- Rapid Sand Filters – NSF/ANSI
- High-Rate Sand Filters – NSF/ANSI
- Pre-Coat Filters – NSF/ANSI
- Filter Media – NSF/ANSI
- Cartridge Filters – NSF/ANSI
- Bottom Drains/Main Drain System – ASME
- Pumps – NSF/ANSI, UL, California Assembly Bill, NEC
- Heaters, HVAC, and Dehumidifiers – UL
- Combustion/Furnaces – ANSI, CSA 2.6-2006 Ga, UL
- Boilers – ASME, ANSI, CSA
- Gas-fired POOL Heaters – ANSI, CSA
- Flues – UL
- Mechanical Chemical Feeding Equipment – NSF/ANSI, UL, CSA
- Ozone – NSF/ANSI, UL, CSA, NEC
- Ultraviolet Light – NSF/ANSI, UL, CSA, NEC
- In-line and Brine Batch Electrolytic Chlorinator or Bromine Generator – NSF/ANSI, UL, CSA, NEC, Canadian PMRA
- Copper/Silver and Copper Ion Generators – NSF/ANSI, UL, CSA, NEC, Canadian PMRA
- Chemical STORAGE – National Fire Code

⁷² ASHRAE. 2013 ASHRAE Handbook—Fundamentals. Accessed 03/23/14 from <https://www.ashrae.org/resources-publications/handbook/description-of-the-2013-ashrae-handbook--fundamentals>

- AUTOMATED CONTROLLERS – NSF/ANSI, UL, CSA, NEC
- WATER QUALITY TESTING DEVICE – NSF/ANSI
- Electrical – NEC
- Lights – UL
- Diving Boards and Platforms – NSF/ANSI
- Starting Blocks – ANSI/NSPI, FINA, NFSHSA, NCAA
- Lifeguard Chairs – NASI/NSPI
- Ladders – ANSI/NSPI
- Handrail – ANSI/NSPI
- Stairs – ANSI/NSPI
- Handicapped Lifts – Americans with Disabilities Act
- Safety Covers – ANSI/NSPI, ASTM, UL

4.3.2 Recirculation Systems and Equipment

D&C

Inlets

D&C

At the release date of this current version of the MAHC, INLET products are currently listed by NSF to an engineering specification. Language is ready for ballot into NSF/ANSI Standard 50.

Overflow System / Gutters

D&C

At the release date of this current version of the MAHC, overflow system gutters products are currently listed by NSF to an engineering specification. Language is ready for ballot into NSF/ANSI Standard 50.

Skimmers

D&C

At the release date of this current version of the MAHC, NSF/ANSI Standard 50 2010 is the current version of the applicable STANDARD for SKIMMERS.

Main Drain System

D&C

At the release date of this version of the MAHC, American National Standards Institute /Association of Pool and Spa Professionals (ANSI/APSP) STANDARD 16 – 2011, titled “American National Standard for Suction Fittings for Use in Swimming Pools, Wading pools, Spas and Hot Tubs” is the current version of the applicable STANDARD for main drain systems.

Multiport Valves

D&C

At the release date of this current version of the MAHC, NSF/ANSI Standard 50 2010 is the current version of the applicable STANDARD for multiport valves.

Face Piping

D&C

At the release date of this current version of the MAHC, face piping products are currently listed by NSF to an engineering specification. Currently at the Task Group Level for development of language for inclusion into NSF/ANSI Standard 50.

Diaphragm Valves**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 14 – 2008e is the current version of the applicable STANDARD for diaphragm valves. Product is currently at the Task Group Level for development of language for inclusion into NSF/ ANSI.

Check Valves**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 14 – 2008e is the current version of the applicable STANDARD for check valves. Product is currently at the Task Group Level for development of language for inclusion into NSF/ ANSI Standard 50 as well.

Fittings**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 14 – 2008e is the current version of the applicable STANDARD for fittings. Product is currently at the Task Group Level for development of language for inclusion into NSF/ ANSI Standard 50 as well.

Pipe**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 14 – 2008e is the current version of the applicable STANDARD for pipe. Product is currently at the Task Group Level for development of language for inclusion into NSF/ ANSI Standard 50 as well.

Pumps**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 - 2010, UL 1081 (non-metallic pumps up to 5 Hp), California Assembly Bill 1953 and United States National Electrical Code NFPA- 70 (2008) are the current version of the applicable STANDARDS for pumps.

Strainers**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for strainers.

Gauges**D&C**

At the release date of this current version of the MAHC, gauges are currently listed by NSF to an engineering specification. Currently at the Task Group Level for development of language for inclusion into NSF/ ANSI Standard 50.

Flow Meters**D&C**

At the release date of this current version of the MAHC, flow meters are currently listed by NSF to an engineering specification. Currently at the Task Group Level for development of language for inclusion into NSF/ ANSI Standard 50.

4.3.2, cont. Heaters**D&C****HVAC and Dehumidifiers****D&C**

At the release date of this current version of the MAHC, UL 1995 is the current version of the applicable STANDARD for HVAC and dehumidifiers.

Solar Pool Heaters**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for solar POOL heaters.

Furnaces**D&C**

At the release date of this current version of the MAHC, ANSI Z83.8-2006 Gas Heaters and Gas-Fired Duct Furnaces, CSA 2.6 -2006 Gas Heaters and Gas-Fired Duct Furnaces and UL 757 Oil-Fired Furnaces are the current version of the applicable STANDARDS for furnaces.

Boilers**D&C**

At the release date of this current version of the MAHC, ASME Boiler Code, ANSI Z21.13 – CSA 4.9 Gas Fired HOT WATER Boilers are the current version of the applicable STANDARDS for boilers.

Gas-Fired Pool Heaters**D&C**

At the release date of this current version of the MAHC, ANSI Z21.10.3 CSA 4.3 and ANSI Z21.56/ CSA 4.7 is the current version of the applicable STANDARDS for gas-fired POOL heaters. Currently under review for inclusion into NSF/ ANSI Standard 50.

Flues**D&C**

At the release date of this current version of the MAHC, UL 1777 is the current version of the applicable STANDARD for flues.

4.3.2, cont. Filtration**D&C****Rapid Sand Filters****D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for rapid sand filters.

High-Rate Sand Filters**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for high-rate sand filters

Precoat Filters**D&C**

Filters previously known as diatomaceous earth filters changed to precoat filters based on significant use of alternate filter media such as perlite. At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for precoat filters.

Filter Media**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for filter media.

Cartridge Filters**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for cartridge filters.

Other Filter Types**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for other filter types.

4.3.2, cont. Disinfection Equipment**D&C****Mechanical Chemical Feeding Equipment****D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 – 2010 and UL 1081, CSA C22 are the current versions of the applicable STANDARDS for mechanical chemical feeding equipment.

Ozone**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 - 2010, UL 1081, CSA C22 and United States National Electrical Code NFPA- 70 (2008) are the current versions of the applicable STANDARDS for ozone generators.

Ultraviolet Light**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 – 2010, NSF/ ANSI Standard 50 – 2010 Annex H, NSF/ ANSI Standard 50 – 2010 Annex H Section 13.11 optional testing for Cryptosporidium validation, CSA C22 and United States National Electrical Code NFPA- 70 (2008) are the current versions of the applicable STANDARDS for ultraviolet light systems.

Other Potential guidance can be found in the USEPA UV Design Guidance:

http://www.epa.gov/safewater/DISINFECTION/lt2/pdfs/guide_lt2_uvguidance.pdf.

In-line Electrolytic Chlorinator**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 - 2010, UL 1081, CSA C22, United States National Electrical Code NFPA- 70 (2008) and Canadian PMRA are the current versions of the applicable STANDARDS for in-line electrolytic chlorinators.

Brine Batch Electrolytic Chlorine or Bromine Generator**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 - 2010, UL 1081, CSA C22, United States National Electrical Code NFPA- 70 (2008) and Canadian PMRA are the current versions of the applicable STANDARDS for brine batch electrolytic CHLORINE or bromine generators.

Copper/Silver and Copper Ion Generator**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 - 2010, UL 1081, CSA C22, United States National Electrical Code NFPA- 70 (2008) and Canadian PMRA are the current versions of the applicable STANDARDS for copper/ silver and copper ion generators.

Chemical Storage**D&C**

At the release date of this current version of the MAHC, United States National Fire Code NFPA- 1 (2009) is the current version of the applicable STANDARD for chemical STORAGE.

Automated Controllers**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 - 2010, UL 61010-1, CSA C22.2, and United States National Electrical Code NFPA- 70 (2008) are the current versions of the applicable STANDARDS for AUTOMATED CONTROLLERS.

Water Quality Testing Device**D&C**

At the release date of this current version of the MAHC, NSF/ ANSI Standard 50 2010 is the current version of the applicable STANDARD for WATER QUALITY TESTING DEVICES.

4.3.2, cont. Electrical**D&C****National Electrical Code****D&C**

At the release date of this current version of the MAHC, United States National Electrical Code NFPA- 70 (2008) is the current version of the applicable STANDARD for general electrical.

Lights**D&C**

At the release date of this current version of the MAHC, UL 1241 – Junction Boxes for Swimming Pool Luminaires, UL 676- Underwater Luminaires and Submersible Junction Boxes, UL8750- Light Emitting Diode (LED) Equipment for Use in Lighting Products, and UL379- Transformers for Fountain, Swimming Pool, and Spa Luminaires are the current versions of the applicable STANDARDS for lights.

4.3.2, cont. Deck Equipment**D&C****Diving Boards and Platforms****D&C**

At the release date of this current version of the MAHC, ANSI/ NSPI- 1 2003 is the current version of the applicable STANDARD for diving boards and platforms.

Starting Blocks**D&C**

At the release date of this current version of the MAHC, ANSI/ NSPI- 1 2003, FINA, NFSHSA, and NCAA are the current version of the applicable STANDARDS for starting blocks.

Life Guard Chairs**D&C**

At the release date of this current version of the MAHC, ANSI/ NSPI- 1 2003 is the current version of the applicable STANDARD for lifeguard chairs.

Ladders**D&C**

At the release date of this current version of the MAHC, ANSI/ NSPI- 1 2003 is the current version of the applicable STANDARD for ladders.

Handrail**D&C**

At the release date of this current version of the MAHC, ANSI/ NSPI- 1 2003 is the current version of the applicable STANDARD for handrail.

Stairs**D&C**

At the release date of this current version of the MAHC, ANSI/ NSPI- 1 2003 is the current version of the applicable STANDARD for stairs.

Handicapped Lifts**D&C**

At the release date of this current version of the MAHC, the AMERICANS WITH DISABILITIES ACT is the applicable STANDARD for handicapped lifts and is regulated by the Department of Justice.

Safety Covers**D&C**

At the release date of this current version of the MAHC, ANSI/ NSPI- 1 2003, ASTM 1346, and UL2452 are the current version of the applicable STANDARDS for SAFETY covers.

4.4 Aquatic Venue Operation and Facility Maintenance**4.5 Aquatic Venue Structure****4.5.1 Design for Risk Management****LG**

Working with the owner and/or aquatic risk management consultant, the designer can outline the anticipated zones of PATRON surveillance and place fixed lifeguard stations accordingly. It is important to have a person knowledgeable in aquatic risk management to advise on placement of fixed lifeguard stations and the general design of the AQUATIC VENUE as it relates to placement of lifeguards so to avoid blind spots, glare issues, and other obstructions being included in the design. This also allows the owner to influence design so it meets the anticipated labor requirements. In some operations where the POOL design requires more lifeguards, this puts pressure on owners to minimize labor by extending zones of PATRON surveillance. Small design changes could reduce zone size without taking away from PATRON enjoyment.

4.5.2 Bottom Slope D&C

4.5.2.1 Parameters and Variance D&C

Special uses include THERAPY POOLS, scuba DIVING POOLS, special training POOLS and other uses that require depth variances without compromising public SAFETY and health.

4.5.2.2 Under 5 feet D&C

A maximum slope of 1:12 is used in water under 3 feet (91.4cm) for consistency with ADA since these ramps can be used for access. Variances may be considered by the AHJ.

4.5.2.4 Drain D&C

POOLS should be designed to allow for the water to drain to a low point in order to prevent standing water from creating a contamination issue.

4.5.3 Access Ladders/Recessed Steps/Stairs

4.5.4 Pool Access/Egress D&C

4.5.4.1 Accessibility D&C

As required by the Department of Justice, all POOL designs shall be compliant with the Americans with Disabilities Act (ADA). The POOL design shall not create SAFETY hazards with regards to maintaining necessary clearances, not infringing upon the recirculation of AQUATIC VENUE water, or creating areas for potential entrapment.

4.5.5 Stairs D&C

4.5.5.3 Deep Water D&C

It is common, especially in high-end diving wells with 10-meter towers, for there to be “swim-out” stairs underneath the dive tower. This provision is allowing for those types of deep water stairs without requiring the stairs to continue down to the bottom of the POOL (which may be 17 feet deep and impractical in the diving well example).

4.5.6 Handrails D&C

4.5.6.5 ADA Accessibility D&C

The outside diameter that the handrail configuration and dimensions need to conform to the POOL access requirements outlined in ADA are not associated with ADA requirements, but these parameters are intended to address the necessary structural requirements which is not addressed in ADA. In the end, ADA STANDARDS will always take precedence over anything in the MAHC.

Another source for guidance is the Architectural Barrier’s Guide – refer to Swimming Pools, Wading pools, and Spas section number 242 and 1009.

4.5.7 Grab Rails **D&C**

4.5.8 Recessed Steps **D&C**

4.5.9 Ladders **D&C**

4.5.9.1 General Guidelines for Ladders **D&C**

4.5.9.2 Ladder Hand Rails **D&C**

ADA Accessibility **D&C**

This a similar response as with the handrail and grab rail comments in MAHC Annex section 4.5.6.5. The MAHC Committee is not intending to only pick certain aspects of ADA to enforce; they agree that all components of the current ADA requirements will stand irrespective to the MAHC language. However, ADA does not address structural requirements.

4.5.9.2.4 Pool Wall **D&C**

This is a design criterion for POOLS in some of the western states. The initial intent was to design against entrapment between the railing and the POOL wall -- both for fingers and also the hands/wrists/arms of smaller children. CPSC recommends 4 inches based on child anthropometry tables.

4.5.9.2.7 Concentrated Load **D&C**

The structural requirements in the ladder, handrail, railing section are taken from commercial manufacturers and their recommended data.

4.5.9.3 Ladder Treads **D&C**

4.5.10 Zero Depth (Sloped) Entries **D&C**

4.5.11 Disabled Access **D&C**

4.5.11.1 Conform to Guidelines **D&C**

Please refer to the governing Department of Justice at www.access-board.gov.

4.5.12 Color and Finish **D&C**

4.5.12.1 White or Light Pastel **D&C**

POOL floors and walls should be white or light pastel in color such that the following items can be identified from the POOL DECK:

- Person or body submerged in the water,
- Algae growth,
- Debris or dirt within the POOL, and
- CRACKS in surface finish of the POOL.

The term “light pastel color” should be consistent with Munsell color value 6.5 or higher.

School, facility or team logos incorporated on the POOL finishes are acceptable but will require review by the AHJ to ensure the design of such logos do not impede the color and finish functionality listed above.

Ultimately, water clarity is the primary criteria with which to be concerned. If a POOL has crystal clear water conditions and a BATHER is lying on the floor of a POOL with a blue finish versus one with a white finish, it's logical to think that the BATHER would be more identifiable against the darker finish. However, there's also the argument for recognizing dirt and debris at the bottom of the POOL.

4.5.12.1.1 Munsell Color Value

D&C

The State of Wisconsin uses the Munsell color chart and requires values of 6.5 or greater. The Munsell color system looks at color purity, hue, and lightness to assign a value. This system is used in other industries and information on this system is easily available.

A contractor could provide a mock-up during the submittal process to the AHJ or engineer for review and approval. Plaster and other quartz aggregate manufacturers have reflectance testing that is available for finish samples.

The American Plasterer's Council defers to ASTM Standard E 1477 – 98a title “Standard Test Method for Luminous Reflectance Factor of Acoustical Materials by Use of Integrating Sphere Reflectometers” to determine LRV values. It's a fairly simple test method where "Test specimens are measured for (total) luminous reflectance factor by STANDARD color-measurement techniques using a spectrophotometer, tristimulus (filter) colorimeter, or other reflectometer having a hemispherical optical measuring system, such as an integrating sphere. The specular component is included to provide the total reflectance factor condition. The instrument STANDARD is referenced to the perfect reflecting diffuser. Luminous reflectance factor is calculated as CIE tristimulus value Y for the CIE 1964 (10°) standard observer and CIE standard illuminant D 65 (daylight) or F 2 (cool white fluorescent).

4.5.13 Walls

4.5.14 Structural Stability

D&C

Expansion and/or CONSTRUCTION JOINTS should be utilized when determined prudent by a licensed structural engineer. Any joints should utilize waterproofing strategies such as water stops as they are subject to compromising a POOL's integrity regarding water tightness. The condition of all joints should be inspected regularly to ensure their condition.

4.5.15 Hand Holds **D&C****4.5.16 Infinity Edges** **D&C****4.5.16.1 Perimeter Restrictions** **D&C**

Often with INFINITY EDGE POOLS, the space immediately on the other side of the INFINITY EDGE is an inaccessible area because the DECK needs to end in order to achieve the “infinity” effect—typically this is achieved by an elevation difference—the DECK continues to extend around the POOL perimeter, but below the edge. The MAHC Technical Committee goal was to allow these types of design features while ensuring that these areas of the POOL are still readily accessible for emergency response.

4.5.16.3 Handholds **D&C**

INFINITY EDGES can be accomplished with an obtuse angle or knife edge, or even a C701 handhold. It is typically submerged a fraction of an inch.

4.5.16.6 Maximum Height **D&C**

Building CODES typically require a railing for heights greater than 30 inches (0.76 m) for SAFETY purposes.

4.5.17 Underwater Benches **D&C**

UNDERWATER BENCHES are intended to allow BATHERS to sit in locations along the POOL wall. These chair/bench-like structures either protrude into the POOL from the POOL wall or are recessed into the POOL wall. To accommodate the size of most people, the seat itself is often 16” (400 mm) to 18” (450 mm) wide and is located 12” (300 mm) to 24” (0.6 m) below the water line.

4.5.17.1 Slip Resistant **D&C**

Slip resistant surfaces shall meet or exceed the minimum coefficient of friction as set forth by the following groups:

- Americans with Disabilities Act (ADA)
- Occupational Safety and Health Administration (OSHA)

4.5.18 Underwater Ledges **D&C****4.5.18.1 Slip Resistant** **D&C**

An UNDERWATER TOE LEDGE for resting (“tired swimmer’s ledge”) may be appropriate in any POOL with water depths greater than 5 feet (1.5 m). They may be provided at the deep end of a competition POOL or other POOL with swim lanes. A ledge for resting may also be provided along the sidewalls of the same POOLS to allow resting for swimmers using the POOL for recreational swimming. A ledge for resting should not allow a person to use the ledge to cross from a shallow area into a deeper area of a POOL. A distance of at least 10 feet (3.0 m) is recommended between the drop-off into the deep area and the start of the ledge.

4.5.18.4 Structural Support D&C

UNDERWATER LEDGES for structural support for an upper wall (structural ledge) are often located at a water depth of about 3 feet (0.9 m) depending on the wall manufacturer. The upper wall is a product manufactured of stainless steel, fiberglass, acrylic, or other materials. The support ledge and wall below the ledge is concrete, gunite, or other materials that the wall manufacturer specifies. Although POOLS using this wall structure are generally smaller POOLS, these POOLS can be any depth.

4.5.19 Underwater Shelves D&C

UNDERWATER SHELVES can be areas such as an expanded top tread of a stairway or a separate area many feet wide and long. The main purpose is often for small children, lounging in very shallow water or in chairs, or contoured as couches.

4.5.20 Depth Markers and Markings

4.5.20.1 Location of Depth Markings RM

4.5.20.1.2 Depth Measurements RM

Non-traditional AQUATIC VENUES such as ACTIVITY POOLS and LAZY RIVERS may have designated entry and exit points and are generally consistent in depth throughout the AQUATIC VENUES. Other AQUATIC VENUES may have landscaping or other BARRIERS so that there is a defined entry such as in a LAZY RIVER. AQUATIC VENUES should install depth markers on the AQUATIC VENUE wall or, when defined entry points are provided, post the depth on entry signs. Consider a variance process.

This requirement is not intended to apply to competition AQUATIC VENUES where skilled divers train and compete in 4-6 feet (1.3-2m) of water and are under the supervision of a certified instructor or coach.

4.5.20.1.3 Below Handhold RM

Vertical depth markings should be provided just below the handhold for POOLS with DECK level gutters. They could also be considered on the wall of the NATATORIUM if within a reasonable distance from the POOL. For DECK level gutter POOLS, vertical depth markings are more visible just below the water level when compared to locating them on a building wall or fence which may be 10 feet (3 m) to 50 feet (15.2 m) away and obstructed by DECK equipment, POOL appurtenances, etc.

4.5.20.1.4 Coping or Deck

4.5.20.1.5 Read on Deck

4.5.20.1.6 25' Intervals

4.5.20.2 Construction / Size

4.5.20.2.1 Durable

4.5.20.2.2 Slip Resistant**4.5.20.2.3 Color and Height****RM**

Depth markers 4 inches (10cm) in height is common among several state CODES and found in ANSI/IAF-9 and ANSI/NSPI-1. Also, Human Factors STANDARDS recommends 1 inch (2.5 cm) of letter height to 10 feet (3 m) of viewing distance for oversized letters or 1 inch of letter height to 16.6 feet (5 m) which is ideal. A 1 inch letter height to 30 feet (9 m) of viewing distance is the minimum.

4.5.20.2.4 Feet and Inches**4.5.20.2.4.1 Abbreviations****RM**

Some states may require both units of measurement in feet, inches and meters. Some states do not allow for abbreviation of units.

4.5.20.3 Tolerance**4.5.20.3.1 Nearest 3 Inches****4.5.20.4 No Diving Markers****4.5.20.4.1 Depths****D&C**

The symbol is required as it is the universally recognized symbol for “no diving” and can be understood by those who do not read and non-English speaking individuals. Diving boards are permitted only when the diving envelope conforms to the STANDARDS of the certifying agency that regulates diving at the facility - National Collegiate Athletic Association (NCAA), the National Federation of State High School Associations (NFSHSA), the Federation Internationale de Natation Amateur (FINA), or U.S. Diving. If the venue does not have competitive diving, then the diving envelope must conform to these diving envelope STANDARDS. The intent of this section is to prohibit recreational and/or unsupervised users from performing DECK level diving into water 5 feet (1.5 m) or shallower. It is not intended to apply to competitive divers competing under the auspices of an aquatics governing body (e.g., Federation Internationale de Natation (FINA), U.S.A. Swimming, National Collegiate Athletic Association (NCAA), National Federation of State High Schools Associations (NFSHSA), YMCA) or under the supervision of a coach or instructor. The vast majority of current STANDARDS allow for diving off the side of the POOL in water 5 feet (1.5 m) deep or greater. Water depths of at least 5 feet (1.5 m) are generally considered as safe for diving from the edge of a POOL where the coping/DECK is the typical 6 inches (150 mm) above the water surface. AQUATIC VENUE size and geometry may necessitate additional depth marking placements about all sides of the AQUATIC VENUE. Spinal Cord Injury Data

The American Red Cross recommends 9 feet (2.74 m) of water depth based on analyses of spinal cord injuries.⁷³ The organization has clarified this recommendation to

⁷³ Cusimano MD, et al. Spinal cord injuries due to diving: a framework and call for prevention. J Trauma. 2008;65(5):1180-5.

state “Be sure water is at least nine-feet deep unless performed with proper supervision and in water depths that conform with the rules of the concerned regulating body, such as USA Swimming, the National Collegiate Athletic Association (NCAA), the Amateur Athletic Union (AAU), the National Federation of State High School Associations (NFHS), YMCA of the USA and the international swimming federation (FINA).”

Although there are some national data on spinal cord injuries (SCIs) in general, data on diving-specific SCIs are limited, particularly for SCIs involving public POOL-related competition diving.

General data on spinal cord injuries: For SCIs in general, approximately 40 SCIs/million population occur each year in the US (about 12,400 injuries for 2010) with approximately 4.5% related to diving injuries.⁷⁴ SCIs are a catastrophic public health problem leading to disability and decreased life expectancy with a large economic and social burden for those that suffer the injury.^{75,76}

DECK level diving and swimming POOL-related SCIs: Most SCIs are related to diving into open water (lakes, ocean)⁷⁷ or use of private/residential POOLS. Analysis of the National Spinal Cord Injury Statistical Center database shows that 341 enrollees from 1973-1986 had an SCI as a result of diving into swimming POOLS⁷⁸. Almost all of the injuries (87%) resulted from diving into private residential POOLS and 57% of injuries were a result of diving into water less than 4 feet (1.2 m) with almost four out of five dives (76.8%) being DECK level dives. Almost half (49%) of injuries involved alcohol use and 46% occurred during parties. In a summary of 194 neck injuries from DECK level dives into in-ground POOLS (33% private residential)⁷⁹, 86.6% where in water less than or equal to 4 ft; 99.0% were in water less than or equal to 5 feet (1.5 m). Only one injury occurred in water between 6 and 7 feet (1.8 to 2.1 m). Another global review study showed that 89% of diving-associated neck injuries occurred in water less than 5 feet.⁸⁰ These data support keeping non-competition DECK level diving to water depths greater than 5 feet (1.5 m).

An example of a “No Diving” Marker:

⁷⁴ DeVivo MJ. Epidemiology of traumatic spinal cord injury: trends and future implications. Spinal Cord. 2012 May;50(5):365-72.

⁷⁵ Blanksby BA, et al. Aetiology and occurrence of diving injuries. A review of diving safety. Sports Med. 1997;23(4):228-46.

⁷⁶ Borius PY, Gouader I, Bousquet P, Draper L, Roux FE. Cervical spine injuries resulting from diving accidents in swimming pools: outcome of 34 patients. Eur Spine J. 2010 Apr;19(4):552-7.

⁷⁷ Barss P, et al. Risk factors and prevention for spinal cord injury from diving in swimming pools and natural sites in Quebec, Canada: a 44-year study. Accid Anal Prev. 2008;40(2):787-97.

⁷⁸ DeVivo MJ, Sekar P. Prevention of spinal cord injuries that occur in swimming pools. Spinal Cord. 1997;35(8):509-15.

⁷⁹ Gabrielsen MA, Spivey M. Diving injuries: The etiology of 486 case studies with recommendations for needed action. 1990. Nova University Press, Ft. Lauderdale, FL.

⁸⁰ DeVivo MJ. Epidemiology of traumatic spinal cord injury: trends and future implications. Spinal Cord. 2012 May;50(5):365-72.



4.5.20.5 Depth Marking at Break in Floor Slope D&C

4.5.20.5.1 Over 5 Feet D&C

A contrasting band is required at the slope transition between shallow water and deep water as an additional means of caution (along with the SAFETY rope and warning signage) to BATHERS.

4.5.20.5.2 Durable D&C

4.5.20.5.3 Safety Rope D&C

4.5.20.6 Dual Marking System RM

4.5.20.7 Non-traditional Aquatic Venues RM

4.5.20.8 Spa Depth Markers RM

“No Diving” symbols are not required in SPAS less than 200 square feet (61m) due to its small size in nature and the minimal distance set for distance between the SPA and adjacent AQUATIC VENUES.

4.5.20.9 Wading Pool Depth Markers RM

A slide RUN-OUT in an aqua-play AQUATIC VENUE may hold up to six inches of water without necessitating a no-diving sign or depth marker.

4.5.20.10 Movable Floor Depth Markers RM

4.5.21 Aquatic Venue Shell Maintenance [N/A]

4.6 Indoor/Outdoor Environment

4.6.1 Lighting

4.6.1.1 General Requirements

4.6.1.2 Windows/Natural Light

4.6.1.2.1 Natural Lighting Methods D&C

This would most likely be achieved through the use of photo sensors that would be triggered by a pre-established minimum light level.

Manual controls would almost certainly be set based on time of day. As the amount of daylight fluctuates throughout the year, these would need to be adjusted.

4.6.1.3 Light Levels D&C

4.6.1.3.1 Minimum Levels D&C

The minimum light levels are as recommended in the Illuminating Engineering Society of North America (IESNA) RP-6-88, "Recommended Practice for Sports and Recreational Area Lighting" for the recreational class of use. Higher light levels are recommended for various competitive classes of use. There is a difference between indoor and outdoor settings because outdoor settings usually have a higher contrast with darkness that does not occur indoors.

4.6.1.4 Overhead Lighting RM

Avoid glare by keeping overhead lighting directed 60-90 degrees horizontal of the eye. Glare on water can be avoided by direct lighting. The more direct the light, the less opportunity for glare. Also consider maintaining a close ratio of the lighting underwater and overhead to obtain a balance thus avoiding glare.

4.6.1.4.1 Artificial Lighting RM

Glare from artificial light that interferes with the lifeguard's view of the swimmers shall be avoided.

4.6.1.5 Underwater Lighting RM

Current regulations specify an under-water light level equivalent to ½ watt per square foot of AQUATIC VENUE surface area. This value is based on outdated incandescent lighting technology.

For today's light sources for higher-efficiency lamps (i.e., more light output per watt), this requirement no longer makes sense. Consider using a measure of light output (e.g., lumens) instead.

Based on an existing 300W General Electric R40 AQUATIC VENUE lamp that produces 3,750 initial lumens of light output, the conversion between watts and lumens is as follows:

$$0.5 \text{ watts/sq.ft.} \times 3,750 \text{ lumens/300 watts} = 6.25 \text{ lumens/sq.ft.}$$

Example:

Lighting comparison between Incandescent & LED lamps for a 2,400 square foot AQUATIC VENUE.

- 300 watt Incandescent Lamps (@ 12.5 lumens per watt = 3,750 lumens per lamp)
 - 2,400sq.ft. x 0.5 watts/sq.ft. x lamp/300watts = 4 lamps
- 30watt LED Lamps (125 lumens per watt = 3,750 lumens per lamp)
 - 2,400sq.ft. x 6.25 lumens/sq.ft. x lamp/3,750 lumens = 4 lamps

Notice that LED lamps are 90% more efficient (lumens/watt) than Incandescent lamps.

“A replacement lamp will need to provide 6.25 lumens per square foot of surface area.”

Additional Information:

The incandescent lamp has an average life of 2,000 hours. For a AQUATIC VENUE that is operational 12 hours per day for 365 days (4,380 hours per year), the incandescent lamp failure rate would be approximately 2 times a year. Note that in-water AQUATIC VENUE lighting remains on when the AQUATIC VENUE is closed to swimming. For the 50,000 hour life of an LED lamp, the failure rate would be 11.4 years.

The AQUATIC VENUE surface replacement would be a determination of replacement lamps and not the lamp itself. Annual energy savings per lamp would be 1,183 KWH.

4.6.1.5.1 Minimum Requirement

D&C

A common practice has been to express underwater lighting requirements in watts per square foot of POOL surface. Light output efficacy (lumens per watt) can vary greatly depending on the light source. Incandescent lighting, the most historically prevalent underwater light source, also has the lowest or worst efficacy. Some of the most common incandescent lamps are listed below, along with their initial lumen output and calculated efficacy:

Lamp	Initial Lumens	Efficacy (Lumens/Watt)
200 Watt PAR 46	2270	11.35
200 Watt PAR 56	2270	11.35
300 Watt PAR 56	3840	12.80
500 Watt PAR 64	6500	13.00

For the purposes of these requirements, the underwater lighting requirements have been converted from incandescent watt equivalents to initial lamp lumens using a conversion factor of 12.0 lumens per watt. The converted watts per square foot of POOL surface requirements are 0.5 watts [outdoor], 1.5 watts [indoor], 1.5 watts [outdoor-diving], 2.5 watts [indoor-diving].

It is recommended that future studies be conducted to determine minimum lighting requirements based on water depth, hours of operation, and overhead lighting design. The main goal is to be able to see the bottom of the POOL, in particular a person on the bottom, at all times when the POOL is open to the public.

4.6.1.5.2 Dimmable Lighting **D&C**

4.6.1.6 Night Swimming with No Underwater Lights **D&C**

4.6.1.6.1 Minimum Requirements **D&C**

Providing higher lighting levels (15 footcandles) than the minimum requirements (10 footcandles) of MAHC Section 4.6.1.3.1 eliminates the requirement for underwater lighting in outdoor POOLS.

4.6.1.7 Emergency Lighting **D&C**

4.6.1.7.1 Emergency Egress Lighting **D&C**

This section isn't intended to provide less stringent requirements, just a baseline STANDARD of design for locales that may not address this requirement. According to several MAHC committee members, 0.5 FC is a fairly STANDARD industry design STANDARD.

4.6.1.8 Glare **RM**

Consider the sun's positioning through different seasons as well as the window placement to avoid glare. Consider moveable lifeguard stands or positions to avoid glare in different seasons. Consider tint and shades when natural light causes glare.

4.6.1.8.1 Windows **D&C**

Windows and any other features providing natural light into the POOL space and overhead POOL lighting should be arranged to avoid glare on the POOL surface that would prevent identification of objects on the POOL bottom.

Careful consideration should be given to the placement of windows and skylights about the POOL. Natural light from directly overhead is less likely to create glare than light through windows at the sides and ends of the POOL.

Control of glare from artificial light is more likely if the angle of incidence of the main light beam is less than 50 degrees from straight down. Diffuse or indirect light sources may also help to minimize glare.

The MAHC Technical Committees had a very difficult time coming to a consensus on MAHC wording regarding glare that could be defended and enforced from a regulatory standpoint. How does a plan reviewer determine that glare based on design documents are excessive (perhaps only in certain months of the year)? The TC felt that design recommendations would be best to address this issue in the annex as things currently stand.

4.6.2 Indoor Aquatic Facility Ventilation

Background of Ventilation and Air Quality Technical Committee Work on the MAHC VEN

Numerous local and state health CODES (N=28) plus the National Environmental Health Association (NEHA) recommendations regarding ventilation were reviewed. The Committee found that:

- Most addressed only moisture control
- The terms used were sometimes vague with 11 of the 28 CODES having very general language typically stating "adequate" or "proper" ventilation without clear definitions of these terms.
- Only three CODES and NEHA specify compliance w/ASHRAE standards.
- Most refer to their state and/or local ventilation and/or mechanical CODE for compliance requirements.
- Only five have developed other state-specific criteria for air TURNOVER and exchange.

As a result of this varied and sometimes vague approach to defining "proper" ventilation, it is critical that the MAHC begins to better define AIR HANDLING SYSTEMS and establish parameters for air quality that reduces the risk of potential health effects. The aquatics industry has always had a challenge with indoor air quality. With the relatively recent increases in building of large indoor waterparks, which have high BATHER LOADS and contamination burdens and exposure times unseen before, indoor air quality is an increasingly important health concern. The media focus in recent years has highlighted this challenge.

Although the AIR HANDLING SYSTEMS of these AQUATIC FACILITIES are quite sophisticated, there are many variables to consider. In addition, much research is still needed in water chemistry and the use of other technologies to improve indoor air quality. The MAHC outlines the design, performance, and operational parameters that can be detailed using data available at the current time. The Annex information provides insight into the

Ventilation and Air Quality Technical Committee's rationale and also identifies areas where more research is needed before additional parameters can be set.

It was the intent of the Technical Committee to require the design of an INDOOR AQUATIC FACILITY to be conducted by a licensed professional engineer with experience in the design of mechanical systems. The Technical Committee approached this section assuming designs will be evaluated by the AHJ in the location in which the system is to be installed.

4.6.2.1 Purpose

VEN

The purpose of the AIR HANDLING SYSTEM is to assure the health and comfort of the users of the AQUATIC FACILITY. A variety of health effects can occur as a result of poor ventilation that leads to accumulation of chemical and biological products in the air. The following section reviews some of the issues of concern for INDOOR AQUATIC FACILITIES.

Chemical By-Products

VEN

The OXIDATION of waterborne organic and inorganic compounds by CHLORINE- or other halogen-based products is a complex process leading to creation of a large number of OXIDATION and DISINFECTION BY-PRODUCTS (DBPs) during the drinking water and aquatic water treatment processes. The source of these compounds is variable but includes source water CONTAMINANTS, BATHER waste (e.g., feces, urine, sweat, skin cells), and environmental introductions (e.g., dirt). Although the identity of many of these compounds is known, many others are uncharacterized and the health effects associated with short and long-term exposure to these compounds are only just starting to be characterized for the aquatic environment. Several of these compounds are known to be volatile and can accumulate in the air surrounding an INDOOR AQUATIC VENUE. Multiple publications discuss the acute and potentially long-term health effects of exposure to these compounds in the aquatic setting.^{81,82,83}

The nitrogenous OXIDATION by-products DICHLORAMINE and TRICHLORAMINE (e.g., chloramines) are known to be irritants that cause acute eye and lung distress. Accumulation of these compounds in indoor settings has been previously documented in several occupational settings where workers routinely use chlorinated solutions to rinse organic products such as poultry^{84,85} and uncooked produce.⁸⁶ Similar symptoms of ocular and respiratory distress have been documented in outbreaks associated with use of indoor aquatic settings.^{87,88,89,90,91,92} Other suspected chloramine-associated

⁸¹ LaKind JS, et al. The good, the bad, and the volatile: can we have both healthy pools and healthy people? Environ Sci Technol. 2010;44(9):3205-10.

⁸² Zwiener C, et al. Drowning in disinfection byproducts? Assessing swimming pool water. Environ Sci Technol. 2007;41(2):363-72.

⁸³ Weisel CP, et al. Childhood asthma and environmental exposures at swimming pools: state of the science and research recommendations. Environ Health Perspect. 2009;117(4):500-7.

⁸⁴ King BS et al. Eye and respiratory symptoms in poultry processing workers exposed to chlorine by-products. Am J Ind Med. 2006;49(2):119-26.

⁸⁵ Sanderson W et al. Case reports: epidemic eye and upper respiratory irritation in poultry processing plants. Appl Occup Environ Hyg 1995;10:43-49.

⁸⁶ Hery M et al. Exposure to chloramines in a green salad processing plant. Ann Occup Hyg 1998;42:437-451.

⁸⁷ CDC. Ocular and respiratory illness associated with an indoor swimming pool — Nebraska, 2006. MMWR Morb

outbreaks are listed in past issues of CDC's Waterborne Disease and Outbreak Surveillance Summaries that can be viewed at <http://www.cdc.gov/healthywater/surveillance/surveillance-reports.html>

Other DISINFECTION BY-PRODUCTS (DBPs) such as the TRIHALOMETHANES have been studied extensively due to their production during treatment of drinking water. These investigations have greatly impacted U.S.EPA water treatment regulations, so there is now a major emphasis on reducing production of DBPs. The effects of these compounds in model systems show long-term exposure associated with chronic health effects such as bladder cancer.^{93,94}

Investigators are beginning to examine the long term health effects of exposure to DBPs during swimming. Although limited, some data suggests the potential for INCREASED RISK of asthma^{95,96} and bladder cancer.⁹⁷ However, many of these studies are ecologic in design, which makes it difficult to definitively link exposures, actual exposure levels, and, swimming.^{98,99,100}

Biological By-Products

VEN

A variety of biological organisms that grow naturally in the environment (e.g., *Legionella*, *Mycobacterium avium* complex and other non-tuberculous mycobacteria, gram negative bacteria) or their constituents (e.g., proteins, lipo-polysaccharides, endotoxin) can be spread in the indoor POOL environment and cause infections^{101,102} and hypersensitivity/allergic reactions (e.g., "Hot tub lung"; "Lifeguard lung", Pontiac

Mortal Wkly Rep 2007;56:929-932.

⁸⁸ Kaydos-Daniels SC et al. Health effects associated with indoor swimming pools: a suspected toxic chloramine exposure. Public Health 2008;122:195-200.

⁸⁹ Bowen A et al. Outbreaks of short-incubation illness following exposure to indoor swimming pools. Environ Health Perspect 2007;115:267-271.

⁹⁰ CDC. Respiratory and ocular symptoms among employees of a hotel indoor waterpark resort --- Ohio, 2007 MMWR Morb Mortal Wkly Rep 2009;58:81-85

⁹¹ Dang B et al. Ocular and respiratory symptoms among lifeguards at a hotel indoor waterpark resort. J Occup Environ Med. 2010;52(2):207-13.

⁹² Hlavsa MC et al. Recreational water-associated disease outbreaks — United States, 2009–2010. MMWR Morb Mortal Wkly Rep. 2014;63(1):6-10.

⁹³ Villanueva CM, et al. Disinfection byproducts and bladder cancer: a pooled analysis. Epidemiology. 2004;15(3):357-67.

⁹⁴ Cantor KP. Carcinogens in drinking water: the epidemiologic evidence. Rev Environ Health. 2010;25(1):9-16.

⁹⁵ Bernard A, et al. Impact of chlorinated swimming pool attendance on the respiratory health of adolescents. Pediatrics 2009;124(4):1110-8.

⁹⁶ Bernard A, et al. Infant swimming practice, pulmonary epithelium integrity, and the risk of allergic and respiratory diseases later in childhood. Pediatrics 2007;119(6):1095-103.

⁹⁷ Villanueva CM et al. Disinfection byproducts and bladder cancer: a pooled analysis. Epidemiology. 2004;15(3):357-67.

⁹⁸ Font-Ribera L, et al. Swimming pool attendance, asthma, allergies and lung function in the Avon Longitudinal Study of Parents and Children (ALSPAC) Cohort. Am J Respir Crit Care Med. 2011;183:582-8.

⁹⁹ Cantor KP. Carcinogens in drinking water: the epidemiologic evidence. Rev Environ Health. 2010;25(1):9-16.

¹⁰⁰ Weisel CP et al. Childhood asthma and environmental exposures at swimming pools: state of the science and research recommendations. Environ Health Perspect. 2009;117(4):500-7.

¹⁰¹ Fields BS et al. *Legionella* and Legionnaires' disease: 25 years of investigation. Clin Microbiol Rev. 2002;15(3):506-26

¹⁰² Falkinham JO 3rd. Mycobacterial aerosols and respiratory disease. Emerg Infect Dis. 2003;9(7):763-7.

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fever).^{103,104,105,106,107} The levels of pathogens and their constituents can be minimized with adequate AQUATIC FACILITY ventilation, maintenance, and required water quality.

4.6.2.2 Exemptions

VEN

The Technical Committee decided that only “buildings” as defined in the building code would be included in the scope of the INDOOR AQUATIC FACILITY definition since there are many variables to consider for places like open buildings (may not have a roof or missing sides) such as variations in weather, geographic zone, etc. that would impact AIR HANDLING SYSTEM design even if one was needed. The guidelines in this module are meant to address the SAFETY and health of users in environments in which air quality is managed by mechanical means due to the “closed” environment since fresh air is not able to freely flow through the building.

4.6.2.3 Indoor Aquatic Facility

VEN

4.6.2.4 Mechanical Code

VEN

4.6.2.5 ASHRAE 62.1

VEN

The hierarchy of design was important in deciding what priorities were taken in the development of the design section. The following hierarchy was determined by the Technical Committee.

- Indoor air quality - chemical, biological, and physical CONTAMINANT load
- Moisture removal – humidity and temperature
- Cost of energy – important to larger sites

When determining the factors a design professional considers, much discussion centered around ASHRAE 62.1 and the parts of design not specifically listed in ASHRAE 62.1 as it applies to INDOOR AQUATIC FACILITIES.

There are two SAFETY functions of the AIR HANDLING SYSTEM: to bring in fresh air and to protect the PATRONS and the building, which requires movement of air. The current ASHRAE 62.1 standard states 0.48 cfm/ft² fresh air is the minimum but still requires TURNOVER. The MAHC needs to consider TURNOVER of air like TURNOVER for AQUATIC VENUES; it should be based on BATHER LOAD and the size and use of the building.

The current STANDARDS approach to ventilation is based on square footage of the AQUATIC FACILITY and yet AQUATIC FACILITIES vary in size. Some facilities have a 20 foot

¹⁰³ Hanak V et al. Causes and presenting features in 85 consecutive patients with hypersensitivity pneumonitis. Mayo Clin Proc. 2007;82(7):812-6.

¹⁰⁴ Sood A et al. Hypersensitivity pneumonitis-like granulomatous lung disease with nontuberculous mycobacteria from exposure to hot water aerosols. Environ Health Perspect. 2007;115(2):262-6.

¹⁰⁵ Rose CS et al. “Lifeguard lung”: endemic granulomatous pneumonitis in an indoor swimming pool. American J Public Health. 1998;88(12):1795-800.

¹⁰⁶ Burnsed LJ et al. Legionellosis Outbreak Investigation Team. A large, travel-associated outbreak of legionellosis among hotel guests: utility of the urine antigen assay in confirming Pontiac fever. Clin Infect Dis. 2007;44(2):222-8.

¹⁰⁷ Tossa P et al. Pontiac fever: an operational definition for epidemiological studies. BMC Public Health. 2006;6:112.

(6 m) ceiling and in the case of indoor waterparks and stadium-style NATATORIUMS, the ceiling heights can reach 60+ feet (18 m). However, the water surface area has a great deal to do with the amount of CONTAMINANTS released into the air.

There are many microclimates in larger AQUATIC FACILITIES with varied AQUATIC VENUES and AQUATIC FEATURES. Air movement will need to be targeted within these microclimates.

The challenge is that ASHRAE 62.1 takes into account the number of users, not the building size. ASHRAE fundamentals require TURNOVER of the volume of air. Designers felt water chemistry, fresh air, BATHER LOAD, water surface area, and distribution of air (barring condensation) are more important than volume TURNOVER.

4.6.2.6 Air Handling System Design VEN

4.6.2.6.1 Mechanical Systems VEN

4.6.2.6.2 Design Factors and Performance Requirements VEN

Known chemical, biological, and physical CONTAMINANTS.

The Technical Committee discussed the various chemical and biological CONTAMINANTS, the availability of testing protocols, and data to support developing health effect thresholds.

Chemical	Biological
Trichloramines	<i>Mycobacterium avium</i> complex
Trihalomethanes	<i>Legionella</i> spp. (primarily <i>L. pneumophila</i>)
Other chlorinated compounds	Endotoxin

The researchers on the committee were able to provide a list of research regarding the thresholds of such CONTAMINANTS that produced symptoms in users of INDOOR AQUATIC FACILITIES. More detailed summaries of these data can be found in Appendix 1: Summary of Health and Exposure Data for Chemical and Biological Contaminants.

After evaluating possible CONTAMINANTS, the committee felt the most frequently detected adverse health symptoms associated with indoor air quality were related to chemical CONTAMINANTS. In evaluating the various chemical CONTAMINANTS, it was found that TRICHLORAMINE was the most prevalent CONTAMINANT reported¹⁰⁸. Therefore, this section

¹⁰⁸ Thickett KM, et al. Occupational asthma caused by chloramines in indoor swimming-pool air. Eur Respir J. 2002;19(5):827-32.

of the MAHC focused on TRICHLORAMINE as the major chemical CONTAMINANT for design considerations.

The table below summarizes findings on the threshold amounts that produced adverse health symptoms.

- | | |
|--------------------------------|----------------------------------|
| • Gagniere 1994 ¹⁰⁹ | 0.5 mg/m ³ |
| • Levesque 2006 ¹¹⁰ | 0.37 mg/m ³ |
| • Hery 1995 ¹¹¹ | 0.5 - 0.7 mg/m ³ |
| • Massin 1998 ¹¹² | 0.5 mg/m ³ |
| • Jacobs 2007 ¹¹³ | 0.56 mg/m ³ (average) |
| • Thickett 2002 ¹¹⁴ | 0.5 mg/m ³ |

In evaluating the TRICHLORAMINE research, it was apparent there is not a single test method used throughout the research. Without a validated test method, it is difficult to compare and benchmark the data from the various studies. As a result, a firm threshold could not be determined solely on the published research to date. Also, without a validated and simple test method, there is not an easy way for health departments or owner/operator to test routinely or with any consistency. For these two reasons, the Technical Committee felt it could not establish a threshold to be enforced by this section of the MAHC at this time. More research using a validated test method may lead to determination of a threshold level in the future. To enforce such a threshold level, the test also needs to be commercially available and easily performed by aquatics staff and health officials.

Therefore, the performance requirements for the AIR HANDLING SYSTEM have parameters for fresh air and dew point/humidity. To accomplish this, several design criteria were kept in mind.

- Fresh air requirements are established to specific levels. The theory is that if the building mechanical system is able to evacuate enough air to remove TRICHLORAMINE, then by default the other airborne CONTAMINANTS would also be evacuated.
- Dew point/humidity levels are set to avoid mold growth and damage to the building structure.

¹⁰⁹ Gagnaire F, et al. Comparison of the sensory irritation response in mice to chlorine and nitrogen trichloride. J Appl Toxicol. 1994;14(6):405-9.

¹¹⁰ Lévesque B, et al. The determinants of prevalence of health complaints among young competitive swimmers. Int Arch Occup Environ Health. 2006;80(1):32-9.

¹¹¹ Hery M, et al. Exposure to chloramines in the atmosphere of indoor swimming pools. Ann Occup Hyg 1995;39(4):427-439.

¹¹² Massin N, et al. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools. Occup Environ Med. 1998;55(4):258-63.

¹¹³ Jacobs JH, et al. Exposure to trichloramine and respiratory symptoms in indoor swimming pool workers. Eur Respir J. 2007;29(4):690-8.

¹¹⁴ Thickett KM et al. Occupational asthma caused by chloramines in indoor swimming-pool air. Eur Respir J. 2002;19(5):827-32.

In the future, if a readily available, STANDARD air testing method for TRICHLORAMINE is developed and a TRICHLORAMINE or other CONTAMINANT threshold can be determined, then it is the recommendation of the Technical Committee that the MAHC adopt such an action threshold for air quality. Additionally, based on the air data threshold set, a threshold should also be re-evaluated and/or revised for combined CHLORINE compounds in water to minimize production and off-gassing of the volatile chloramines. In the interim, bio-MONITORING for TRICHLORAMINES can be effectively accomplished by training POOL operators to be on alert for the distinctive chloramine odor and eye and lung irritation it causes. Since the odor threshold for TRICHLORAMINE is $\sim 0.1 \text{ mg/m}^3$ and, as illustrated above, health symptoms start happening around $0.3\text{-}0.5 \text{ mg/m}^3$, odor MONITORING can generally work well as an early warning system.

It was recognized by the Technical Committee that SECONDARY DISINFECTION SYSTEMS (e.g., ozone, U.V.) could help to reduce the amount of off-gassing of DBPs and therefore would need less volumes of outside air to dilute the concentration of these chemicals in the air. Basic treatment includes the use of CHLORINE or bromine and STANDARD filtration and will require a certain amount of outside air per AQUATIC VENUE type. UV/Ozone or other technology that is used to aid in the reduction of DBPs could reduce the amount of outside air required.

The efficacy of UV and ozone are well documented for their effect on biological CONTAMINANTS but the photochemistry taking place is a different reaction for DISINFECTION vs. controlling combined CHLORINE levels. Further research is needed to determine the effectiveness of UV and ozone on destroying DBPs before they can be considered in the design of an AIR HANDLING SYSTEM. Guidance is included in the MAHC for the use of UV and ozone for DISINFECTION. It is unknown at this time if the parameters for the equipment to achieve DISINFECTION will also result in the reduction of DBPs.

The initial draft of the Ventilation and Air Quality Module included discussion of fresh air requirements for facilities utilizing UV and ozone, which allowed for a reduction in the amount of fresh air required for ventilation compared to basic water treatment. However, until the efficacy of these technologies in reducing DBP formation can be established and parameters can be set in which any installation of these technologies can meet minimum requirements, we cannot include these technologies as a method to reduce fresh air requirements. Such information should be considered when efficacy data become available.

For future development of minimum performance requirements for UV and ozone, one should consider dose as a function of concentration and contact time. Many systems are designed for full flow treatment but contact time is very limited. These minimum parameters may help to attain efficacy, but as noted, more research is required. Below are some proposed statements for use once system efficacy can be determined:

- *The Design Professional may reduce the amount of fresh air with the use of UV and/or ozone if the Design Professional can demonstrate the efficacy of the system and have it validated by a third party. The system must achieve a xxx% reduction of TRICHLORAMINE in a single pass.*

- *The system must be designed to achieve at minimum, a dose of XXX at the highest and lowest flow rate the system would normally operate in.*
- *UV systems must have a wavelength of 254 and/or 282 nm to reduce monochloramine, DICHLORAMINE, and TRICHLORAMINE.*

Another concern is that although it is believed UV and ozone are effective on breaking down TRICHLORAMINE, we do not know its effect on the other CONTAMINANTS such as TRIHALOMETHANES. If one uses the assumption that using fresh air to evacuate TRICHLORAMINE will result in removing other airborne CONTAMINANTS, then one must also consider other chemical CONTAMINANTS. If one reduces the amount of fresh air because a SECONDARY DISINFECTION SYSTEM is used to break down TRICHLORAMINE, it does not mean the other airborne CONTAMINANTS are also destroyed by the SECONDARY DISINFECTION SYSTEM. The photochemistry may be different so efficacy may have to be determined for other compounds.

4.6.2.6.3 Ventilation in Chemical Storage Space VEN

The design for CHEMICAL STORAGE SPACE was included in the initial version of the MAHC Ventilation and Air Quality module AIR HANDLING SYSTEM design posted for public comment. It was, removed in the revised indoor AIR HANDLING SYSTEM design area of the MAHC as part of revising the definition of an INDOOR AQUATIC FACILITY for which the AIR HANDLING SYSTEM does not include CHEMICAL STORAGE SPACE or other space outside the negative pressure zone around the AQUATIC VENUE. However, the building of an INDOOR AQUATIC FACILITY will still require considering the ventilation of CHEMICAL STORAGE SPACES using separate AIR HANDLING SYSTEMS so the text has been moved to MAHC 4.9.2.

4.6.2.7 Performance Requirements for Air Handling Systems VEN

4.6.2.7.1 Minimum Outdoor Air VEN

Significant numbers of public comments were received regarding the proposed increase, above ASHRAE 62.1 STANDARDS of required outdoor air. The commenters noted that the requirements will result in increased costs for equipment and operation while lacking adequate data to support the increase. Based on the potential negative impact and the need for additional research and data to differentiate the causes and sources of indoor air quality problems on design criteria (e.g., design, inappropriate operation, inadequate maintenance), the Steering Committee decided to defer to ASHRAE 62.1 outdoor air requirements in this version of the MAHC. The Steering Committee thought it important to preserve the work done by the Technical Committee, so the proposed code language for additional outdoor air has been moved to Appendix 2 in the MAHC along with preserving the corresponding annex discussion. A research agenda should be developed and should be a priority to better address the contributing factors to indoor air quality problems and the appropriate design and operational requirements needed to address those factors.

4.6.2.7.2 System Alarm VEN

There are several methods to add a MONITORING station to the outside air portion of the AIR HANDLING SYSTEM to establish the volume of exhaust air leaving the AQUATIC FACILITY.

Since a negative pressure must be maintained, by measuring the exhaust, the volume of outdoor air entering through the combination of the outside air vents, doors, and other infiltration methods must be equal to the measured exhaust.

4.6.2.7.6 Relative Humidity/Dew Point

VEN

Maintaining relative humidity within acceptable levels, below 60%, in the INDOOR AQUATIC FACILITY environment is important for a variety of reasons. Research has shown elevated relative humidity levels often coincide with mold growth, damage to building structures, BATHER discomfort, and inadequate ventilation. The engineer should pay particular attention when designing the AIR HANDLING SYSTEM to ensure relative humidity levels can be maintained below the recommended 60% when the INDOOR AQUATIC FACILITY is occupied. It may also be necessary to install properly calibrated and maintained, real-time, relative humidity MONITORING devices inside the AIR HANDLING SYSTEM to ensure the mechanical system can react to changing conditions inside the INDOOR AQUATIC FACILITY. Relative humidity can fluctuate based upon a variety of factors, including occupancy and use of the facility, but a range of 45% to 60% can be accepted.

Additionally, the QUALIFIED OPERATOR and inspection personnel should routinely monitor the relative humidity inside the INDOOR AQUATIC FACILITY. Relative humidity is a ratio, expressed in percent, of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated. Since the latter amount is dependent on temperature, relative humidity is a function of both moisture content and temperature. For consideration in designing the facilities structure, dew point is a better measure of absolute moisture levels.

Dew point has a relationship with relative humidity. A high relative humidity indicates that the dew point is closer to the current air temperature. Relative humidity of 100% indicates the dew point is equal to the current temperature and that the air is maximally saturated with water. For human comfort factors, the maximum relative humidity has been specified for a very narrow range of indoor temperatures and thus is an easily measured and understood metric by users and owners of an AQUATIC FACILITY. For the building design, dew point is a more important metric because the outdoor conditions can be over a very wide temperature range. The design professional must be able to calculate the internal dew point for all building structure components to avoid condensation. Condensation occurs when the inside surface temperatures equal the dew point of the space.

Using a properly calibrated instrument designed to measure relative humidity eliminates the complexity of calculating relative humidity by hand. It is important to collect a series of representative relative humidity measurements inside the INDOOR AQUATIC FACILITY. The building should be divided into representative areas if necessary, depending upon size and various AQUATIC FEATURES. Measurements should be taken from each occupied area. Measurements should be taken at DECK level and recorded. Arithmetic average of measurements will provide an estimation of the relative humidity in the INDOOR AQUATIC FACILITY. This may require consultation with design professionals.

4.6.2.7.8 Disinfection By-Product Removal

VEN

“This information is distributed solely for the purpose of pre-dissemination public comment under applicable information quality guidelines. It has not been formally disseminated by the Centers for Disease Control and Prevention. It does not represent and should not be construed to represent any agency determination or policy.”

It is the Technical Committee's intent not to limit the development of new technologies. Although the efficacy of these technologies are not readily apparent, in the future there is a hope that the CODE will allow for the design professional to decrease the outside air requirements when secondary technology is used and the design professional can prove the efficacy of the added technology. Other methods and technology for decreasing DBPs include:

- Ventilating surge tanks to remove off-gassing TRICHLORAMINE before the water re-enters the POOL area
- Use of a cooling tower to force water to off-gas TRICHLORAMINE before reintroducing water to the POOL area

4.6.2.7.11 Purge

VEN

When an AQUATIC FACILITY has an event (e.g. POOL is shocked) that requires the introduction of a larger volume of outdoor air, the PURGE mode can be manual triggered to provide a flush of the INTERIOR SPACE. Since the outdoor air is not tempered or conditioned in this mode, the length of operating time is limited to provide one air change of the space { (60 cfm) / (ft³) }.

4.6.2.7.12 Air Handling System Filters

VEN

Manufacturers/designers could consider developing/incorporating specialized solid phase (e.g., activated carbon or other media) chloramine removal air filtration as another means to sequester chloramines and potentially reduce fresh air requirements. However, such systems need to show proven efficacy. With new methods development, such systems could eventually be designed with sensors confirming that the combined CHLORINE levels are at an acceptable level (when such air measurement methods become available). If levels increased, then the AIR HANDLING SYSTEM could proportionally increase the amount of outside air.

Air Quality – Health

M&T

No rapid, simple, and commercially available tests for di- and tri-chloramine exist at the current time. However, MONITORING for TRICHLORAMINES can also be effectively accomplished by training POOL operators to be on alert for the distinctive chloramine odor and eye and lung irritation it causes. The odor threshold for TRICHLORAMINE is 0.1 mg/m³ and health symptoms start happening around 0.3-0.5 mg/m³, so odor MONITORING generally works well as an early warning system.^{115,116,117,118,119,120}

¹¹⁵ Gagnaire F, et al. Comparison of the sensory irritation response in mice to chlorine and nitrogen trichloride. J Appl Toxicol. 1994;14(6):405-9.

¹¹⁶ Lévesque B, et al. The determinants of prevalence of health complaints among young competitive swimmers. Int Arch Occup Environ Health. 2006;80(1):32-9.

¹¹⁷ Hery M, et al. Exposure to chloramines in the atmosphere of indoor swimming pools. Ann Occup Hyg 1995;39(4):427-439.

¹¹⁸ Massin N, et al. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools. Occup Environ Med. 1998;55(4):258-63.

¹¹⁹ Jacobs JH, et al. Exposure to trichloramine and respiratory symptoms in indoor swimming pool workers. Eur Respir J. 2007;29(4):690-8.

¹²⁰ Thickett KM et al. Occupational asthma caused by chloramines in indoor swimming-pool air. Eur Respir J.

Air Turnover Rates

M&T

MONITORING CO₂ levels can be used as an alternative to MONITORING air quality/outside air. The facility design engineer should specify what the alternative CO₂ level limit should be. Air TURNOVER can include a few sources: by recycling air from other parts of the building, or using outside air, or a mixture of the two. Use of CO₂ as a MONITORING tool, in addition to odor and humidity control, should be effective for controlling air TURNOVER-related health issues, assuming the facility is designed properly.

4.6.2.7.6 Relative Humidity

M&T

Relative humidity levels should be monitored using a properly calibrated humidity meter.

4.6.3 Electrical Systems and Components

D&C

Nothing in this code should be construed as providing relief from any applicable requirements of the NEC or other applicable code, except where modified by this MAHC.

4.6.3.1 General Guidelines

D&C

Wiring

D&C

Wiring located near or associated with equipment for bodies of water should be installed in compliance with the NEC or with other applicable code, except where the MAHC is more restrictive.

- See NEC Art. 100 “Location, Wet”.
- See NEC Art. 110.11 “Deteriorating Agents”.

Sealed Conduit

D&C

Electrical conduit that enters or passes through a NATATORIUM should be sealed at the point of entry into the NATATORIUM against the movement of liquids and vapors through the conduit. Exceptions may include:

- A conduit which only passes through a NATATORIUM, and which has no fittings or joints exposed to NATATORIUM air, should be acceptable without a seal.
- Rigid or intermediate conduit which passes through a NATATORIUM, and which is assembled with threaded couplings only should be acceptable without a seal where at least three threads are engaged at every joint.
- Conduit which passes through a NATATORIUM, and which is assembled with rain-tight compression fittings only should be acceptable without a seal.
- Otherwise-approved non-metallic conduit assembled by glued joints or other solvent-welding method shall be acceptable without a seal where approved by the AHJ.

Note: An explosion-proof seal is not required, unless by the AHJ.

- See NEMA 250, National Electrical Manufacturers Association.
- See CSA C22.2, Canadian Standards Association.
- See UL 50, Underwriters Laboratories.
- See UL 508, Underwriters Laboratories.
- See NEC Art. 110.11, “Deteriorating Agents”.

Where such devices must be installed in a NATATORIUM or in spaces containing NATATORIUM air, ENCLOSURES rated NEMA 4X are preferred.

Electric Panels

D&C

Electrical panel boards, distribution centers, motor-control centers, fuse panels, circuit-breaker panels, and similar equipment should not be installed in NATATORIUMS or in any space that normally contains NATATORIUM air. Exceptions may include:

- Equipment which is listed and labeled for the conditions should be acceptable where approved by the AHJ.
- Where SAFETY switches or equipment-disconnect switches must be installed in a NATATORIUM or in spaces containing NATATORIUM air, e.g. per NEC, they should be rated for the conditions.
- Whips consisting of liquid-tight flexible metal conduit are preferable to BX cable or type AC conduit.
- See NEMA 250, National Electrical Manufacturers Association.
- See CSA C22.2, Canadian Standards Association.
- See UL 50, Underwriters Laboratories.
- See UL 508, Underwriters Laboratories.
- See NEC Art. 110.11, “Deteriorating Agents”

Exposed Wiring

D&C

Where NATATORIUM lights, attachments, fasteners, and any associated wiring whips are exposed to NATATORIUM air, they should be rated for the conditions.

- See NEC Art. 250-110(2).
- See International Association of Electrical Inspectors, Soares Book on Grounding, 8th Ed., 2001, p157.
- See Croft, Terrel and Summers, Wilford, American Electricians’ Handbook, Ed.12, Sec. 9-340(b).
- See ANSI/IEEE 241, Sec 5.17.6.

Metal Raceways

D&C

Metal raceways should be equipped with a grounding conductor sized according to NEC Article 250 to maintain device ground potential in the event of degradation of the raceway.

- See NEMA 250, National Electrical Manufacturers Association.
- See CSA C22.2, Canadian Standards Association.

- See UL 50, UL 508, Underwriters Laboratories.
- See NEC Art. 110.11, “Deteriorating Agents”.

Any electrical switch installed in a NATATORIUM shall be rated for the atmosphere. Exception may include a switch which is otherwise protected, as in a gasketed weather-tight box with a weather-tight actuator cover shall be acceptable.

4.6.3.1.2 Natatoriums

D&C

- See NEC Art. 300.7.
- See Durston, Lee. Design, Construction, and Testing of the Commercial Air Barrier. Accessed at http://www.irinfo.org/articles/5_1_2009_durston.pdf
- US Army Corps of Engineers . 2012. Air Leakage Test Protocol for Building Envelopes. Accessed at:
- http://www.nec.net/sites/default/files/nec CODES/Air-Tightness-Air-Leakage_Final.pdf, and
- http://www.wbdg.org/pdfs/usace_airleakagetestprotocol.pdf

4.6.3.2 Electrical Equipment in Interior Chemical Storage Space

D&C

Raceways

D&C

All raceways and raceway devices and boxes in a CHEMICAL STORAGE SPACE should be non-metallic or otherwise rated for the atmosphere.

- See NFPA 70HB08, Art. 100, “Labeled”, Explanatory Note.
- See NEC Art. 110.11, “Deteriorating Agents”.
- See NEC Art. 378.10, “Non-Metallic Raceways”.
- See Croft, Terrel and Summers, Wilford, American Electricians’ Handbook, Ed. 12, Sec. 9-340(b).
- See MSDS calcium hypochlorite, Sec. 10 Stability and Reactivity Data.
- See MSDS sodium hypochlorite, Sec. 10 Stability and Reactivity Data.
- See MSDS hydrochloric acid, Sec. 10 Stability and Reactivity Data.
- See MSDS muriatic acid, Sec. 10 Stability and Reactivity Data.

Sealed

D&C

Raceways should be sealed at the point of entry to the CHEMICAL STORAGE SPACE to prevent the egress of liquids, fumes, vapors, and gases from the chemical-STORAGE space via the conduit.

Note: Explosion-proof seals are not required, unless by the AHJ.

- See NEC Art. 300.7.
- See Durston, Lee, *Design, Construction, and Testing of the Commercial Air Barrier*.

Metal Raceways**D&C**

Metal raceways should be equipped with a grounding conductor sized according to NEC Article 250 to maintain device ground potential in the event of degradation of the raceway.

- See NEC Art. 250-110(2) International Association of Electrical Inspectors, *Soares Book on Grounding*, 8th Ed., 2001, p157.
- See Croft, Terrel and Summers, Wilford, *American Electricians' Handbook*, Ed. 12, Sec. 9-340(b).
- See ANSI/IEEE 241, Sec 5.17.6.

Electronics**D&C**

All electrical equipment, devices and fixtures should be listed and labeled for the expected atmosphere of the space.

- See NFPA 70HB08, Art. 100, "Labeled", Explanatory Note.
- See NFPA 70HB08, Art. 100, "Listed", FPN.

Light Switches**D&C**

Any light switches installed inside interior CHEMICAL STORAGE SPACES should be approved for use in wet and corrosive atmospheres, or shall be otherwise protected, as by a weather-proof actuator cover with a gasket.

- See NEC Art. 110.11, "Deteriorating Agents".

Permanent Electrical Devices**D&C**

All permanently connected electrical devices should be grounded per the NEC or other applicable code, using a separate grounding conductor which does not depend on the conductive integrity of any metal conduit exposed to chemical-STORAGE space air.

- See NEC Art. 250-110(2) International Association of Electrical Inspectors, *Soares Book on Grounding*, 8th Ed., 2001, p157.
- See Croft, Terrel and Summers, Wilford, *American Electricians' Handbook*, Ed. 12, Sec. 9-340(b).
- See ANSI/IEEE 241, Sec 5.17.6.

4.6.3.2.1 Wet and Corrosive**D&C**

- See NEC Art.100 "Location, Wet".
- See NEC Art. 110.11, "Deteriorating Agents"
- See MSDS calcium hypochlorite, Sec. 10 Stability and Reactivity Data
- See MSDS sodium hypochlorite, Sec. 10 Stability and Reactivity Data
- See MSDS hydrochloric acid, Sec. 10 Stability and Reactivity Data
- See MSDS muriatic acid, Sec. 10 Stability and Reactivity Data

4.6.3.2.2 Electrical Conduit**D&C**

- See NEC Art. 300.7.
- See NEC Art. 110.11, “Deteriorating Agents”
- See MSDS calcium hypochlorite, Sec. 10 Stability and Reactivity Data
- See MSDS sodium hypochlorite, Sec. 10 Stability and Reactivity Data
- See MSDS hydrochloric acid, Sec. 10 Stability and Reactivity Data
- See MSDS muriatic acid, Sec. 10 Stability and Reactivity Data

4.6.3.2.3 Electrical Devices

D&C

Electrical panelboards, circuit breakers, disconnects, motors, motor overloads, and similar devices or equipment are included.

- See NEC Art. 110.11, “Deteriorating Agents”
- See Zalosh, Robert, Dust Explosion Fundamentals, NFPA.

4.6.3.2.4 Protected Against Breakage

D&C

- See MSDS calcium hypochlorite, Sec. 7 Handling and Storage, “Keep away from heat. Keep away from sources of ignition.”
- See MSDS calcium hypochlorite, Sec. 10 Stability and Reactivity Data

4.6.4 Pool Water Heating

Evaporation Control

D&C

Other CODES do not address the need for constant control of NATATORIUM air temp in order to control evaporation. They also do not address the need for heat on specific surfaces.

NATATORIUM heating equipment should be selected and installed to preserve compliance with the NEC, the National Fuel Gas Code (if applicable), the INTERNATIONAL MECHANICAL CODE, or other applicable CODES, the terms of equipment listing and labeling, and with the equipment manufacturer’s installation instructions.

A method of space heating capable of continuously maintaining the temperature of the air in a NATATORIUM at or above the design temperature relative to the POOL-water temperature shall be provided. ASHRAE 99.6% climate data is the most reliable for NATATORIUM load calculations.

- See *ASHRAE Handbook of Fundamentals*¹²¹

Uncontrolled Condensation

D&C

Uncontrolled condensation in a building can lead to the growth of molds, with subsequent health effects. Uncontrolled condensation in a building can lead to property damage from rust, rot, ice pressure, and other.

¹²¹ ASHRAE. 2013 ASHRAE Handbook—Fundamentals. Accessed 03/23/14 from <https://www.ashrae.org/resources-publications/handbook/description-of-the-2013-ashrae-handbook--fundamentals>

Condensation can be controlled by:

- Controlling the evaporation rate of the water,
- Controlling the temperature and relative humidity of the room air, and
- Maintaining all exposed building surfaces above room-air dew point.

Evaporation Rate

D&C

The POOL evaporation rate is affected by the:

- Size of the POOL,
 - Agitation of the water,
 - Heat of vaporization of the water at that temperature and pressure,
 - Temperature difference between the POOL-water and the room air and the associated difference in vapor pressures, and
 - Speed of the air over the POOL's surface.
- See Places of Assembly, *ASHRAE Handbook of Fundamentals*¹²²

Example for Note: A design POOL-water temperature is 82°F (27.8°C) with a design air temperature of 84°F (28.9°C). It is decided to raise the POOL-water temperature to 83°F (28.3°C); the air temperature should be raised to 85°F (29.4°C) to maintain the same evaporation rate. Any surface which is exposed to room air and which cools below the dew point of the room air will become wet with condensation. Such surface may not be visible, e.g. inside a wall.

Space Heating

D&C

- Space heating should be available year-round.
- Space heating should not be disabled seasonally.

Exceptions may include:

- Space heating need not be provided during such times as the POOL(S) may be drained completely, all AQUATIC FEATURES and other evaporative loads are disabled and drained, and the room relative humidity does not rise above the design range.
- Space heating may not be required if ventilation with outdoor-air is sufficient to prevent room temperature from falling below the design range, and room relative humidity from rising above the design range.

Seasonal Disabling

D&C

Where POOLS are filled or partially filled, the evaporation rate will increase as room air temperature decreases. Seasonal disabling of space heating could allow a drop of room

¹²² ASHRAE. 2013 ASHRAE Handbook—Fundamentals. Accessed 03/23/14 from <https://www.ashrae.org/resources-publications/handbook/description-of-the-2013-ashrae-handbook--fundamentals>

temperature, with a subsequent increase in evaporation rate and possible uncontrolled condensation.

Surfaces where the temperature may decrease below the design dew point of the space under normal operation shall be identified as part of the design process. At least one inspection should be done during the first heating season to identify any other such surfaces. The addition of heat to surfaces identified may be necessary to maintain their temperature above the design dew point for the space. Where forced air is used to heat identified surfaces, the heating method specified shall be so installed as to heat the room's air supply. The temperature, flow rate, and delivery of the supply air for each identified surface shall be such as to heat that surface above the design dew point of the space, under the worst-case design conditions. Such surfaces may have low values of thermal resistance. Such surfaces may include, but are not limited to windows and their frames, doors and their frames, any metal structural members that penetrate the vapor retarder, and any under-insulated sections of walls or roofs.

- See Thermal and Water Vapor Transmission Data, *ASHRAE Handbook of Fundamentals*¹²³

Combustion Heaters

D&C

Where combustion space heaters or combustion heaters required are located inside a building, the space in which the heater(s) or an assembly including the heater(s) is located shall be considered to be an EQUIPMENT ROOM for the purposes of MAHC section 4.9.1. The requirements of MAHC section 4.9.1 shall apply. Exceptions may be made for space heaters listed and labeled for installation in the atmosphere shall be acceptable without ISOLATION from chemical fumes and vapors.

Note: Not all space heaters listed for heating NATATORIUM air are listed for installation in a NATATORIUM. Combustion space heaters should not be installed in a NATATORIUM, unless the heater is rated for the atmosphere.

4.6.4.1 High Temperature

D&C

This temperature limit shall not be construed to be the limit of the bulk water temperature. Bulk-water temperature limits are much lower, e.g. UL 1563. The limit of MAHC section 4.6.3.1.1 is for heating devices which heat a stream of water that is to be returned to the POOL, SPA, etc. Such devices must heat the water stream above the bulk-water temperature limit, but either

- Should not heat the water stream above the limit of MAHC Section 4.6.3.1.1, or
- Mixing or other methods should be employed to prevent PATRON exposure to temperatures above the limit of MAHC Section 4.6.3.1.1.¹²⁴

¹²³ ASHRAE. 2013 ASHRAE Handbook—Fundamentals. Accessed 03/23/14 from <https://www.ashrae.org/resources-publications/handbook/description-of-the-2013-ashrae-handbook--fundamentals>

¹²⁴ Moritz AR and Henriques FC. Studies of thermal injury: The relative importance of time and surface temperature in the causation of cutaneous burns. *Am J Pathol.* 1947 Sep;23(5):695-720.

Examples of “applicable CODES” include but are not limited to the National Electric Code, the National Fuel Gas Code (if applicable), NFPA 70, and the INTERNATIONAL MECHANICAL CODE 304.1.

4.6.4.4 Equipment Room Requirements

D&C

Combustion heaters should not be installed in a NATATORIUM, or exposed to other chemical fumes, unless the heater is rated for the atmosphere.

4.6.5 First Aid Room

4.6.5.1 Station Design

LG

A conveniently designated first aid station location should be provided for use when BATHERS report with minor injuries and/or illness. The first aid station must be easy to locate and must have first aid supplies to care for minor injuries and more serious injuries until emergency assistance can arrive. Some AQUATIC FACILITIES may have a formal First Aid Station that is a standalone and others may have a location for first aid equipment. The committee felt it would allow for flexibility in design to call out the location for first aid equipment rather than designate a stand-alone station. Some AQUATIC FACILITIES are large and a single first aid station is not as practical as distributing first aid equipment throughout the AQUATIC FACILITY (e.g., to individual AQUATIC VENUES). From a design standpoint, the designer must address the location of such equipment and as stated in MAHC Section 4.5, should work with the owner and/or aquatic risk management consultant to designate these locations.

4.6.6 Emergency Exit

4.6.7 Drinking Fountains

D&C

4.6.7.1 Provided

D&C

A drinking fountain is required at an AQUATIC FACILITY simply to encourage swimmers not to drink the POOL water and to keep swimmers hydrated. At an outdoor AQUATIC FACILITY, the drinking fountain can be located inside an adjacent building to allow year-round use when the AQUATIC FACILITY is closed for the winter. The drinking fountain would not need to be winterized. When a drinking fountain is not located in the AQUATIC FACILITY, it should not be located more than 25 feet (7.62 m) from the AQUATIC FACILITY entrance. The AHJ may approve a bottled water supply in place of a drinking fountain. The water from a bottled water supply shall be as readily accessible to BATHERS as would the water from a drinking fountain.

4.6.8 Garbage Receptacles**4.6.9 Food and Drink Concessions****4.6.10 Spectator Areas****D&C****4.6.10.1 Within Aquatic Facility Enclosure****D&C****4.6.10.2.1.1 Barrier****D&C**

The MAHC committee tried to distinguish the word “BARRIER” from “ENCLOSURE.” Those definitions are in the glossary. As currently defined, a “BARRIER” is simply intended to be an obstacle intended to deter direct access from one point to another. For example, a simple post and rope solution would meet our intent.

4.6.10.3 Balcony**D&C**

The intent is to prevent people from using a balcony as a diving platform. If a balcony is close to overhanging an AQUATIC VENUE, some people may try and use it to jump or dive into the AQUATIC VENUE. The more substantial and preventative the BARRIER at the balcony is, the less likely is that a person will use it.

4.6.10.4 Bleachers**D&C**

Many building code jurisdictions may not be aware of the new ICC 300 bleacher standard. Once jurisdictions adopt the 2007 International Building Code and supplements, the bleacher CODE will become better known.

4.7 Recirculation and Water Treatment**4.7.1 Recirculation Systems and Equipment****4.7.1.1 General****R&F*****Rationale for Prescriptive Approach******R&F***

Recirculation and water treatment systems guidance tends to be more prescriptive than performance based because it is quite difficult and expensive to measure the performance of the filtration and RECIRCULATION SYSTEM with regard to pathogen removal and/or inactivation. Even the measurement of water clarity (e.g., turbidity) can be difficult (due to potential bubble formation, instrument fouling, and instrument calibration procedures) and can cost more than a thousand dollars to continuously measure turbidity at a single point.

Reasons to Exceed the Minimum Standards***R&F***

There is no single TURNOVER time or one type of filtration system that is optimal for every POOL. Requiring the most aggressive design for every AQUATIC VENUE is not the intent of the MAHC (or even necessary). However, some AQUATIC VENUES, particularly those with high numbers of BATHERS per unit water volume, could need higher recirculation rates and more efficient filtration than the minimum STANDARDS. Since it is

not always possible to predict the number of BATHERS in a POOL, the MAHC recommends a modest overdesign of the RECIRCULATION SYSTEM pipes and thus ample space be left for expansion of pumping and filtration capacities, which will be referred to henceforth as the hydraulic flexibility recommendation. Future editions of the MAHC could have higher minimum STANDARDS that AQUATIC FACILITIES might wish to comply with without having to remove and replace a lot of concrete to accommodate slightly larger pipes.

Hydraulic Flexibility Recommendation

R&F

The hydraulic flexibility recommendation made in the section above will also reduce friction losses in the pipes that may lead to energy savings and reduced operating costs. With the formalization of a new turndown system for AQUATIC VENUES, it is hoped that AQUATIC VENUES may be designed for worst-case conditions and then operated according to the demands placed on the system. A turndown system could be used to operate below the minimum operational STANDARDS set by the MAHC when the AQUATIC VENUES is not occupied as an additional cost-saving measure as long as water quality criteria are maintained.

4.7.1.2 Combined Aquatic Venue Treatment

R&F

There are some important considerations to take into account when considering combined AQUATIC VENUES treatment, and this practice is generally discouraged for most installations. First, to respond to a contamination event, it would be necessary to shut down all AQUATIC VENUES and water features on a combined AQUATIC VENUE treatment system since contamination of one AQUATIC VENUE would rapidly contaminate all combined AQUATIC VENUES. Second, including an INCREASED RISK AQUATIC VENUE on a combined system would require secondary DISINFECTION to be installed for all AQUATIC VENUES on the RECIRCULATION SYSTEM. The two scenarios would involve isolating *Cryptosporidium* to a single AQUATIC VENUE (limiting the number of BATHERS exposed while keeping the concentration high) or diluting it as much as possible between all AQUATIC VENUES (to limit the maximum concentration or exposure level while increasing the number exposed). Based on the infectious dose concept (i.e., the number of OOCYSTS required to be ingested to cause an infection), diluting *Cryptosporidium* or other CONTAMINANTS is one way of reducing outbreak potential but the high numbers of *Cryptosporidium* OOCYSTS that may be excreted (e.g., 10^8 - 10^9 per contamination event^{125,126}) may overwhelm modest dilution factors while greatly increasing the number of people exposed. While the number of BATHERS exposed may increase, the exposure level will decrease if circulation rates were the same meaning dilution of a very small AQUATIC VENUE into a large POOL might reduce the *Cryptosporidium* level from 1000's of OOCYSTS per mL swallowed to less than 1 per mL in the combined system. However, smaller AQUATIC VENUES can be circulated at faster rates through the SECONDARY DISINFECTION SYSTEM and therefore can have OOCYSTS loads reduced faster if they are in a small volume, rapidly circulating AQUATIC VENUE. Design modeling is needed to

¹²⁵ Chappell CL et al. *Cryptosporidium parvum*: intensity of infection and oocyst excretion patterns in healthy volunteers. J Infect Dis. 1996 Jan;173(1):232-6.

¹²⁶ Goodgame RW et al. Intensity of infection in AIDS-associated cryptosporidiosis. J Infect Dis. 1993 Mar;167(3):704-9.

compare the efficacy of these two scenarios under different OOCYST concentrations. The dilution scenario only works if an INCREASED RISK AQUATIC VENUE of small volume is combined with a large volume AQUATIC VENUE. For AQUATIC VENUES similar in size, the impact of dilution is small while the number of people exposed might double or more. There could also be benefits with a combined system that would make it easier to provide more stable water quality parameters (in terms of pH and CHLORINE level) because larger water volumes tend to be easier to control. Again, the potential positive impact of combined treatment is limited to combining small POOLS with much larger POOLS, which is not likely if the DISINFECTION requirements differ between the AQUATIC VENUES. Hydraulically isolating a given AQUATIC VENUE on a combined treatment system with valves is discouraged because doing so necessarily prevents filtration and recirculation of the water. However, ISOLATION capabilities are recommended for maintenance purposes (as well as separate drain piping).

4.7.1.3 Inlets

R&F

4.7.1.3.1 General

R&F

Flow Velocity

R&F

The velocity of flow through any INLET orifice (at between 100% and 150% of the total recirculation flow rate chosen by the designer) should normally be in the range of 7 to 20 feet per second (2 to 6 m/s). The range of velocities through the INLETS was selected to balance two competing goals. The velocity should be high enough to push water effectively to the center of the POOL (or to within the range of the floor INLETS for wider POOLS), but the velocity should not be so high as to waste an unnecessary amount of energy. The INLETS still being within design range at 150% of the design recirculation flow rate is to accommodate the hydraulic flexibility recommendation discussed previously. This recommendation ensures proper operation at both the current and any future flow rates up to at least 150% of the recirculation flow.

4.7.1.3.2 Floor Inlets

R&F

Maintain and Measure

R&F

The use of floor INLETS might require additional considerations for draining them when the POOL is not in use. The likelihood of biofilm proliferation in pipes not in use is thought to increase significantly as the FREE CHLORINE RESIDUAL is dissipated. Drinking water distribution pipes are normally coated with biofilm even in the presence of a constant CHLORINE residual^{127,128}. Since it is more difficult to inactivate microorganisms in a biofilm¹²⁹, there is potentially INCREASED RISK of human exposure to pathogens shielded by biofilm once the POOL reopens. Leoni and coworkers found mycobacteria in 88.2% of POOL water samples analyzed and reported that swimming POOLS provided a suitable

¹²⁷ Niquette P, Servais P, Savoir R. Impacts of pipe materials on densities of fixed bacterial biomass in a drinking water distribution system. *Water Research*. 2000;34(6):1952-1956.

¹²⁸ Goeres DM et al. Evaluation of disinfectant efficacy against biofilm and suspended bacteria in a laboratory swimming pool model. *Water Research*. 2004;38(13):3103-3109.

¹²⁹ Goeres DM et al. Evaluation of disinfectant efficacy against biofilm and suspended bacteria in a laboratory swimming pool model. *Water Research*. 2004;38(13):3103-3109.

habitat for the survival and reproduction of mycobacteria¹³⁰. Significant damage to the RECIRCULATION SYSTEM pipes and surroundings can result from the expansion of water as it freezes. Both dangers may be alleviated by simply draining water from the pipes when the POOL is not in use. Provisions might also be recommended to prevent the pipes from refilling with water once drained.

4.7.1.3.3 Wall Inlets R&F

4.7.1.3.3.1 Effective Mixing R&F

For STANDARD POOLS, since the majority of the water leaving the POOL does so at the surface, locating the INLETS 24-inches (61 cm) below the design operating water level would reduce short-circuiting of water from the INLETS to the surface removal system.

4.7.1.3.3.3 Inlet Spacing R&F

Wall INLETS have a limited range for how far they can push water out toward the center of the POOL especially as the flow of water is being pulled out of the POOL at the wall via gutters or SKIMMERS. The likelihood of forming regions in the center of the POOL that are not efficiently filtered or chlorinated increases as the width of the POOL increases. For POOLS less than 4 feet (1.2 m) in depth, the average velocity of the water is thought to be increased as the volume of water served by a single INLET is expected to decrease assuming equal spacing.

Floor INLETS are thought to more effectively distribute chlorinated filtered water to the center of the POOL thereby reducing the magnitude or likelihood of dead zones in the center of the POOL. For this reason floor INLETS are required for POOLS greater than 50 feet in width. The designer should take into account climate when designing the INLET system and provide proper drainage instructions.

4.7.1.3.3.3.3 Recessed Areas R&F

Step areas, swim outs, and similar recessed or isolated areas are likely to create a dead zone. Placement of one or more INLETS in these areas will help ensure distribution of chlorinated, filtered water to these areas.

4.7.1.3.3.5 Dye Test Procedures in Appendix R&F

See Appendix 3 for Dye Test Procedures.

Dye testing should be performed to determine and adjust the performance of the RECIRCULATION SYSTEM. Dye studies tend to be qualitative in nature¹³¹.

A dye test may not be necessary for “STANDARD” designs previously determined to provide effective mixing. It may be particularly important for irregular shaped POOLS.

¹³⁰ Leoni E et al. Prevalence of *Mycobacteria* in a swimming pool. Environment. J. Applied Microbiology. 1999;87(5):683-688.

¹³¹ Alberta. Pool Standards, 2006 for the Swimming Pool, Wading Pool, and Water Spray Park Regulation. (Last accessed 1/1/2011). <http://www.health.alberta.ca/documents/Standards-Pools.pdf>

Some judgment is generally required to determine whether a dye study should be classified as passing or a failing. In general, dead zones (or areas of poor circulation) would indicate a failure that could be fixed by adjusting the INLETS or other system hydraulics. If the POOL does not reach a uniform color within 15-20 minutes, then adjustments are required.

4.7.1.4 Overflow Systems/Gutters R&F

4.7.1.4.1 General R&F

4.7.1.4.1.1 Skimming R&F

Perimeter Overflow/Gutter Systems (POS) are intended to remove surface water from the POOL (SPA, etc.) for treatment and recirculation. They need to remove water from all parts of the POOL equally. Much of the dirt, oil, bacteria, floating debris and possibly undissolved chemicals are in the top inch of water. There may also be less DISINFECTANT due to aerosolization and oxidant demand. Indoors, there is some evidence that DISINFECTION BY-PRODUCTS build up in the top layer where they are more likely to aerosolize and contribute to poor air quality and BATHER discomfort.

Areas that do not have good circulation due to lack of gutters or return grates (e.g., ZERO-DEPTH ENTRIES) or which have gutters that are not level may not have adequate flow in these areas and may develop “dead spots” where the DISINFECTANT is not present at adequate levels to prevent recreational waterborne illnesses or algae growth. The corners of POOLS with SKIMMERS are a case in point. Unsightly debris such as “oil slicks”, blowing paper, dead bugs and leaves may also collect in these “dead zones”.

Designs R&F

Novel designs (e.g., gutters located on only the two longest sides of the POOLS) should be subject to approval by the local authority with proper engineering justification (e.g., a computational fluid dynamics (CFD) model of the POOL design demonstrating acceptable hydraulic balance and mixing).

4.7.1.4.2 Gutter Size and Shape R&F

Continuous Water Removal R&F

A value of 125 percent of the total recirculation flow rate chosen by the designer is recommended for hydraulic flexibility.

Oversizing the SKIMMER capacity for “point surge. As PATRONS swim, play, dive, and splash, they create waves that exceed the normal recirculation one might see when the POOL is empty. Upsizing the gutter system allows capture of the waves without flooding the gutter, which would make the gutter ineffective. Human body density is approximately equal to water (fat is less and muscle is more) at approximately 1 g/mL. A 200 pound person displaces approximately 24 gallons. (200 lbs. x 0.454 kg/lb. x 1L/kg x 0.264 gal/L = 24 gallons) The average PATRON is not 200 pounds, so this conservative parameter provides extra capacity in the surge system for more dynamic wave instances.

Surge capacities recommended by state health departments of 1 gallon per square foot of POOL water are common. For an average of 24 (typically 16 to 30) square feet of water per person and 24 gallons per person to be conservative, the net surge capacity is 1 gallon per square foot of POOL. This is not new information and was considered over a decade ago. The State of Iowa tried 2 gal/ft² for a few years, but found that to be unnecessary. It continues to work well in POOL designs. Once again, the oversized gutter system is recommended to account for how PATRONS enter and displace the POOL water adjacent to the gutter. The 125% gutter capacity and the 1 gallon of surge per square foot of area both continue to work well in practice. The gutter capacity must be even greater for designs relying on AQUATIC FEATURES and slide flow being returned through the gutter.

4.7.1.4.3 Gutter Outlets R&F

4.7.1.4.3.1 Design Capacity R&F

A value of 125 percent of the total recirculation flow rate chosen by the designer is recommended for hydraulic flexibility. The design goal is to avoid inadequate outlet SPACING in these old gutter channels. The SPACING between drain outlets should not exceed 10 feet (3 m) for two inch (5.1 cm) diameter drains or 15 feet (4.6 m) for two and one half inch (6.4 cm) drains, unless hydraulically justified by the design engineer.

4.7.1.4.4 Surge Tank Capacity R&F

4.7.1.4.4.1 Net Capacity R&F

The net capacity shall be measured from the minimum operating depth required to maintain pump suction to the bottom of the overflow waste outlet.

Draining R&F

Surge tanks should be provided with means for complete draining to allow routine inspections, maintenance, and cleaning. Proper maintenance will reduce the chances of biofilm formation and bio-corrosion. Surge tanks should also have a means of draining for winterization, where applicable. An overflow is recommended to prevent a POOL from flooding DECK areas (indoor) if over filled and flooding filter rooms during rainfall events. An air break is recommended to prevent a cross-connection with the POOL water that could introduce CONTAMINANTS into the POOL.

Contain R&F

Surge tanks can contain valves, piping, float controls, heating system manifolds or heat exchangers, makeup water controls and large basket screens for large AQUATIC FACILITIES. They also can act as a settling basin for large particles and debris coming directly from the main drains and gutters. It is reasonable to drain these tanks to access equipment and remove settled materials.

4.7.1.4.5 Tolerances R&F

Gutter tolerances were chosen to keep water flowing in even proportions from all sections of the POOL and to avoid dead spots and scum lines. Tighter tolerances may be needed for competitive POOLS.

4.7.1.4.6 Makeup Water System

R&F

Other BACKFLOW prevention devices may include the following:

- reduced pressure principle assembly (RP),
- pressure vacuum breaker assembly (PVB),
- spill-resistant vacuum breaker assembly (SVB), or an
- atmospheric vacuum breaker assembly (AVB).

All devices may not be appropriate for all installation conditions.

4.7.1.5 Skimmers

R&F

4.7.1.5.1 General

R&F

4.7.1.5.1.2 Provided

R&F

The use of SKIMMERS could be limited to POOLS with surface areas of less than 1,600 square feet (149 m²), and the maximum width for POOLS using SKIMMERS could be restricted to less than 30 feet (9.1 m). The use of SKIMMERS has been limited to smaller POOLS with light BATHER LOADS since their inception. The limitations of SKIMMERS versus gutters appear to be physical in nature. For example, a 30 ft x 50 ft (9.14 m x 15.24 m) POOL may be served 3 SKIMMERS rated at 500 square feet each. If each SKIMMER is 1 foot wide, then all of the skimmed water is being drawn off from only 3 foot of the POOL perimeter (i.e., 1.9 % of the total perimeter). This would lead to higher water velocities over the floating weirs and water being collected from a greater depth (as opposed to actual surface skimming) relative to a gutter system that extends around the perimeter of the POOL. In this example, 98.1% of the perimeter of the POOL is not being used to skim water and could produce regions of limited flow and scum collection. Theoretically, enough SKIMMERS might be added to produce effective skimming comparable to a gutter system, but the research to demonstrate this in practice could not be found. Practical experience says that having no scum lines or dead zones in corners with stagnant debris are inherent advantages. There could also be practical hydraulic limitations for heavily loaded POOLS related to use of in-POOL surge as opposed to a surge tank. Equalizer lines are recommended to prevent SKIMMERS from pulling air into the pump and potentially causing loss of prime, flow surges, and interference with proper filter operation.

4.7.1.5.1.3 Hybrid Systems

R&F

Hybrid systems that incorporate surge weirs in the overflow gutters to provide for in-POOL surge shall meet all of the requirements specified for overflow gutters. Since the number of BATHERS determines the type of surface overflow system in use, the hybrid systems should be able to meet all code requirements regardless of how many BATHERS are present and which components are in active use.

When the POOL is in quiescent condition (no BATHERS in the water) the surge weirs provide surface skimming. The operating water level during the period when there are no BATHERS in the water is designed to be below the rim of the gutter and flows over the surge weirs by gravity. When BATHERS enter the water, the level rises (in-POOL surge capacity) , the surge weir openings close, and the water flows over the gutter as in STANDARD gutters.

4.7.1.5.1.3.1

Surge Weir

R&F

The manufacturers of these gutter systems typically have flow capacities (gpm/surge weir) established for their surge weirs. The number of surge weirs necessary to accommodate the portion of the recirculation rate to be removed from the surface is calculated by using the percentage of the total recirculation rate for surface skimming (i.e., 80 % of total flow) divided by the flow rate for each surge weir. The total recirculation rate must not be used for this calculation, as it will result in a greater number of surge weirs; operationally less water will need to be removed from the surface, which will likely result in inadequate flows over the weirs for effective surface skimming.

4.7.1.5.1.3.1.1

Locations

R&F

The required number of surge weirs are to be uniformly spaced around the POOL perimeter in the gutter.

4.7.1.5.1.4

Design Capacity

R&F

The 100 percent of the total recirculation flow rate chosen by the designer is recommended as part of the hydraulic flexibility recommendation.

4.7.1.5.2

Skimmer Location

R&F

4.7.1.5.3

Skimmer Flow Rate

R&F

NSF Standard

R&F

SKIMMERS should provide for a flow-through rate of 30 gallons per minute (1.9 L/s), or 3.75 gallons per minute per linear inch (9.3 L/s/m) of weir, whichever is greater. The AHJ may approve alternate flow-through rates so long as the SKIMMERS are NSF or equivalent listed and manufacturer's design specifications are not exceeded.

4.7.1.5.4

Control

R&F

4.7.1.5.5

Tolerances

R&F

4.7.1.5.6

Testing

R&F

Flotation Test Procedure

R&F

Materials Needed:

- Yellow wooden stars (55 -110 minimum depending on the POOLS surface area)
- Video camera

- Tripod

Conditions Prior to Test:

- TURNOVER time and recirculation flow rate are operated as normal for the POOL
- INLETS and outlets are positioned as normal for the POOL
- SKIMMERS or gutter system is not flooded
- If using SKIMMERS make sure that the weirs are present
- Water level is at the appropriate height above the weir/gutter (about ¼")
- Set up video camera to record

Test 1: Circulation

1. Determine how many stars are necessary by using the following:
 - POOL surface area < 2,500 sq ft. use a minimum of 55 stars
 - POOL surface area > 2,500 sq ft. use a minimum of 110 stars
2. Randomly toss the stars into the POOL. Try to toss the stars so that there is an even distribution throughout the surface of the POOL.
3. Record and observe the stars as they travel.
4. Record the motion of the stars in each area of the POOL (e.g., clockwise, counter-clockwise, no movement) and any other observations.
5. Passing criteria may vary, but suggestions include 90% removal within 1 hour.

Test 2: Skimmer/Gutter Draw

1. Stand behind one of the SKIMMERS or the gutter and drop a star into the water at arm's length distance (about 2 ft) in front of it.
2. Record how long it takes for the star to enter the SKIMMER or gutter. Then repeat this process at the same location three times.

4.7.1.6	Submerged Suction Outlet	R&F
4.7.1.6.1	General	R&F
4.7.1.6.2	Number and Spacing	R&F
4.7.1.6.3	Tank Connection	R&F
4.7.1.6.4	Flow Distribution and Control	R&F
4.7.1.6.4.1	Design Capacity	R&F

The 125% of the total recirculation flow rate chosen by the designer is recommended as part of the hydraulic flexibility recommendation MAHC Annex 4.7.1.1. The proportioning valve(s) are recommended to restrict flow by increasing the head loss in the pipe(s) typically on the main drain lines where flow rates are less than those from the surface overflow system lines.

The main drain system shall be designed at a minimum to handle recirculation flow of 100% of total design recirculation flow rate. A minimum of two hydraulically balanced filtration system suction outlets are required as protection from suction entrapment. The branch pipe from each main drain outlet shall be designed to carry 100% of the recirculation flow rate so in the event that one drain outlet is blocked the other has the capacity to handle the total flow.

Where three or more main drain outlets are connected by branch piping in accordance with MAHC section 4.7.1.6.2.1.1 through 4.7.1.6.2.1.3, , it is not necessary that each be designed for 100% flow. Where three or more properly piped drain outlets are provided, , the design flow through each drain outlet may be as follows;

- Q_{max} for each drain= $Q(\text{total recirculation rate})/(\text{number of drains less one})$
- $Q_{\text{max}}=Q_{\text{total}}/(N-1)$

The result is that if one drain is blocked, the remaining drains will cumulatively handle 100% of the flow.

EXAMPLE:

-600 gpm recirculation rate

-3 drains

$600/(3-1)=300$ gpm /drain.

4.7.1.6.5 Flow Velocities R&F

4.7.1.7 Piping R&F

4.7.1.7.1 Design R&F

4.7.1.7.2 Velocity in Pipes R&F

4.7.1.7.2.1 Discharge Piping R&F

RECIRCULATION SYSTEM piping should be designed so the water velocities should not exceed 8 feet (2.4 m) per second on the discharge side of the recirculation pump. This is a maximum value as opposed to a good design value. The head loss in a pipe (and hence the energy loss in the RECIRCULATION SYSTEM) is proportional to the square of the velocity in the pipe (i.e., if you cut the velocity in half, then you reduce the head loss to ¼ (25%) of the original value). In the interest of conserving energy, velocities in the range of 6 to 8 feet (1.8 m x 2.4 m) per second are recommended. Without a minimum INLET velocity, uniform water distribution within the supply piping will not happen.

4.7.1.7.2.2 Suction Piping R&F

The maximum velocity in suction piping is 6 feet (1.8 m) per second. The real limitation in suction piping is net positive suction head (NPSH) recommended by the pump. Net

positive suction head refers to the pressure energy at the suction INLET to the impeller. Pump problems can result from incorrect determination of NPSH. Inadequate NPSH can reduce pump efficiency and capacity and lead to cavitation. If cavitation continues and the pump conditions deteriorate, vibration problems can lead to destruction of the pump impeller and damage to other pump hardware. Failure to provide sufficient NPSH for the pump can result in cavitation, high power usage, and premature failure of the pump and other RECIRCULATION SYSTEM components. The velocities recommended could be lower depending on the size and configuration of the piping as well as the elevation and water temperature. The available NPSH should be at least 20% greater than the recommended NPSH. The available NPSH should be calculated for each AQUATIC VENUE pump and each AQUATIC FEATURE pump. The available NPSH should be compared with the NPSH recommended by each pump manufacturer. Cavitation will occur if the available NPSH is less than the recommended NPSH. The available NPSH is calculated as follows: absolute pressure on the liquid surface - friction losses in the suction line – vapor pressure of the water + static head of liquid above impeller eye (all terms in feet). Hydraulic calculations for piping and pumps should be prepared by a qualified engineer.

4.7.1.7.2.3 Additional Considerations

R&F

Gravity piping must be sufficiently sized to accommodate the recommended flow (including surges) without water surcharging above the INLET. Careful consideration of available head, the head losses, and the combined flow from multiple inputs into a single pipe is a necessity. The 2 feet per second value is a value derived from common practice with no clearly identifiable theoretical basis.

4.7.1.7.3 Drainage and Installation

R&F

Draining Recommendation

R&F

The draining recommendation for all equipment and piping serves multiple functions. First, any sediment or rust particles that gather in the pipe can be flushed by means of the drainage system. Since bacteria and biofilms are mostly water, drying out a biofilm can be an effective means of controlling growth. Whereas leaving a pipe full of water during a period of maintenance or no use could lead to dissipation of the CHLORINE residual and proliferation of a biofilm inside of pipes and/or equipment. Biofilms can lead to bio-corrosion of metal components of the RECIRCULATION SYSTEM and serve as protection for microbes and pathogens.

Designed

R&F

All equipment and piping should be designed and constructed to drain completely by use of drain plugs, drain valves, and/or other means. All piping should be supported continuously or at sufficiently close intervals to prevent sagging and settlement. All suction piping should be sloped in one direction, preferably toward the pump. All supply and return pipe lines to the AQUATIC VENUE should be provided to allow the piping to be drained completely.

Individual Drain

R&F

The individual drain to facilitate emptying the POOL in case of an accidental gross contamination event is intended to prevent further contamination of any pipes, pumps, multi-port valves, filters, or other equipment associated with the RECIRCULATION SYSTEM, which might be more difficult to clean than the inside of the AQUATIC VENUE. In the case of combined AQUATIC VENUE treatment systems, this drain could prevent cross-contamination of multiple AQUATIC VENUES.

4.7.1.7.4 Piping and Component Identification **R&F**

4.7.1.7.4.1. Clearly Marked **R&F**

Clearly marking pipes will prevent misidentification that could lead to cross-connections and contamination of the AQUATIC VENUE. Pipe marking will also facilitate easier identification of locations for additional equipment installation and/or sample lines.

Color Coding Recommendations: Pipes and valves, when color-coded, may be color-coded in accordance with the following:

- Potable water lines (Dark blue),
- Backwash waste (Dark brown),
- Filtered water (Aqua),
- Sewer (Dark gray),
- SKIMMER or gutter return (Olive green),
- DECK drains (Light brown),
- Main drain (Black),
- Alum (Orange),
- CHLORINE (gas/solution) (Yellow),
- Compressed air (Dark green),
- Soda ash (White),
- Gas (Red), and
- Acid (Pink).

4.7.1.7.5 Testing **R&F**

4.7.1.8 Strainers and Pumps **R&F**

4.7.1.8.1 Strainers **R&F**

4.7.1.8.2 Pumping Equipment **R&F**

4.7.1.8.2.1 Variable Frequency Drives **R&F**

Variable frequency drives (VFDs) may be allowed because the energy savings could be substantial if flow is reduced at night and water quality criteria are continuously maintained. At this time, we are not aware of public health benefits or deficits associated with VFD use so these pumps are allowed but not required. Operators should be aware that VFDs can flatten out a pump curve so if they are installed on a filter pump, operators may want more active control to maintain operations. It is

recommended that operators use VFDs with a compatible flow meter with a feedback control to optimize VFD function.

4.7.1.8.2.2 Total Dynamic Head R&F

The recirculation pump should be selected to meet the recommendations of the designer for the system. However, the following guidelines are suggested as starting points for designers. The recirculation pump(s) must be selected to provide the recommended recirculation flow against a minimum total dynamic head of the system, which is normally at least 50 feet (15.2 m) for all vacuum filters, 70 feet (21.3 m) for granular media and cartridge filters, or 60 feet (18.3 m) for precoat filters. A lower total dynamic head could be shown to be hydraulically appropriate by the designer by calculating the total head loss of the system components under worst-case conditions.

4.7.1.8.3 Operating Gauges R&F

Pressure Measurements R&F

A second set of pressure measurement ports could be recommended (tapped into the pump volute and discharge casing) to accurately calculate the flow of the pump. These gauges are a way of verifying the pump curve is correct. One can also use the pressure/vacuum gauges and pump curve to verify the flow meter reading and look for differences between the two. During startup, it is possible to shut off a valve on the discharge side of the pump and verify that the maximum discharge pressure measured agrees with the value on the pump curve.

It is recommended that all pumps be located on a base so as to be easily accessible for motor service.

Vacuum Limit Switches R&F

The vacuum limit switch is intended to shut down the pump if the vacuum increases to a point which could cause damage to the pump (cavitation).

4.7.1.9 Flow Measurement and Control R&F

4.7.1.9.1 Flow Meters R&F

Over 22% (approximately 20,000) of the POOL inspections that led to POOL closures in the state of Florida in 2012 were caused by non-functioning flow meters. This section of the MAHC is intended to improve this flow meter reliability problem (as well as to address a problem with accuracy). Since flow rates are critical for proper filtration, sizing, and operational calculations, it is recommended that operators purchase a more accurate flow meter for all systems or when replacing older flow meters on their existing system. Improved accuracy improves an operator's chance of understanding the true flow in their system. Operators should be mindful of flow meter placement by installing according to manufacturer recommendations and adhering to recommended distance parameters.

A flow meter or other device that gives a continuous indication of the flow rate in gallons per minute through each filter should be provided. If granular media filters are used, a device should be provided to measure the backwash flow rate in gallons per minute for each filter. Flow meters should have a measurement capacity of at least 150% of the design recirculation flow rate through each filter, and each flow meter should be accurate within +/-5% of the actual design recirculation flow rate. The flow measuring device should have an operating range appropriate for the anticipated flow rates and be installed where it is readily accessible for reading and routine maintenance. Flow meters should be installed with 10 pipe diameters of straight pipe upstream and 5 pipe diameters of straight pipe downstream or in accordance with the manufacturer's recommendations. Acrylic flow meters will not meet the accuracy requirement (and are prone to fouling/clogging) and hence should not be installed as the primary flow meter on any RECIRCULATION SYSTEM. However, acrylic flow meters could prove useful as a backup or auxiliary flow meter. A paddle-wheel flow meter, when used, should be located on the effluent side of the filter to prevent fouling.

More accurate flow meters are recommended to conserve energy and increase regulatory compliance. Magnetic and ultrasonic flow meters offer greater accuracy (typically less than +/- 1% error) and less potential for fouling, but the aforementioned flow meters tend to be more expensive (e.g., \$1,000 or more). An ultrasonic flow meter (such as clamp-on transit-time models) can be used to measure flows through the wall of a pipe, so they can be installed and uninstalled without modifying the existing plumbing. One ultrasonic flow meter could be used to routinely verify the flow readings of multiple other flow meters that are more prone to error. An annual cleaning and evaluation of flow meter accuracy could be useful in maintaining compliance with existing regulations.

4.7.1.10	Flow Rates/Turnover	R&F
4.7.1.10.1	Maximum Allowable Flow Rates	R&F
4.7.1.10.2	Calculated	R&F

A new methodology is being proposed for use in the future that calculates the recommended minimum design recirculation flow rate, which is called the maximum sustainable BATHER LOAD (MSBL) calculation. The MSBL calculation is based on the values in MAHC Annex Table 4.7.1.10.2 (below) and adjusted by all applicable multipliers in MAHC Annex Table 4.7.1.10.3 (below) as the maximum TURNOVER time allowable based on the pathogen load and CHLORINE demand imparted by BATHERS. Whereas, the traditional TURNOVER time values (required in MAHC Code Table 4.7.1.10) are based on physical transport processes of CONTAMINANTS and disinfectant in the POOL. The MSBL design TURNOVER rates should use the adjustment factors provided. For mixed-use POOLS, each zone of the POOL should individually meet the recommended TURNOVER time for the zone based on the lesser TURNOVER time calculated by the procedures already described. All of the maximum TURNOVER times provided in MAHC Code Table 4.7.1.10 are required for AQUATIC VENUES as defined in the MAHC. The MSBL values calculated might help to identify POOLS that could be slightly over-designed to meet the demands placed on the AQUATIC VENUE. Furthermore,

the MSBL approach actually identifies risk factors that might require higher or lower levels of treatment based on the actual system.

- Zone Volume (ft³) = Zone Surface Area (ft²) x Average Depth (ft)
- Zone BATHER LOAD Factor (BATHERS/ft³) =
1/ {Surface Area per BATHER (ft²/BATHER)} x (Average Depth (ft))
- Estimated Maximum Number of BATHERS Per Zone =
Zone BATHER LOAD Factor (BATHER/ft³) x Zone Volume (ft³)
- Raw Recirculation Flow Rate Per Zone (gal/min) =
Estimated Maximum Number of BATHERS Per Zone x 5.34 (a constant)
- TURNOVER time (h) = Water volume (gal) / {Recirculation rate (gal/min) x (60 min/ 1 hr)}

Table 4.7.1.10.2: BATHER LOADING Estimates

R&F

Depth (in Feet)	Surface Area Per Bather (square feet)
<3	25
3 to 6	30
6.1 to 10	22
>10.1	16

Table 4.7.1.10.3: Recirculation Rate Multipliers (Adjustment Factors)R&F

Adjustment Reason	Adjustment Factor	Recommendation(s)
Edge Loading (more bather at edge of larger pools)	1.1	Pool must be greater than 100,000 gallons/ Spa > 10,000 gallons
Increased-risk (diaper-aged patrons present)	0.75	Pool designed for at least 10% of patrons to be diaper-aged.
Activity/Line (Attractions increase bather density)	0.5	Any pool/spa with an associated ride or activity (besides swimming) or line to enter
High-temperature (increased sweat production)	0.5	Pool/Spa with water temperatures routinely exceeding 95 F.
Indoor (protected from some environmental factors)	1.15	Pool/Spa must be located completely indoors year round.
Limited-use (pools that are frequently lightly loaded)	1.33	Pool must be at an Apartment, Condominium, or Hotel/Motel with no associated attraction or activity.
Showering recommended (showering reduces bather load)	1.15	Pool/Spa must recommend showering prior to entry.

Example Calculation

R&F

For example, here is a set of example calculations for an indoor POOL in a hotel that is 20 ft wide x 30 ft long with an even floor slope that goes from 4 ft at the shallow end to 6ft at the deep end.

- Zone Volume (ft³) = 20 ft x 30 ft x 5 ft = 3,000 ft³
- Zone BATHER LOAD Factor (BATHERS/ft³) = 1/(30 ft²/BATHER) x (5ft) = 0.00666 BATHERS/ft³
- Estimated Maximum Number of BATHERS Per Zone = 0.00666 BATHER/ft³ x 3,000 ft³ = 20 BATHERS
- Raw Recirculation Flow Rate Per Zone (gal/min) = 20 BATHERS x 5.34 = 106.8 gal/min
- TURNOVER time (h) = 3,000 ft³ x 7.48 gal/ft³/(106.8 gal/min) x (60 min/1 hr) = 3.5 h
- Adjustments for indoor POOL and limited use POOL: 3.5 h x 1.15 x 1.33 = 5.35 h

- Compare the MSBL value of 5.35 h to the value in Table 4.7.1.10.3 of 5 h and use the lower value = 5 h. Additional example calculations are provided in Table 4.7.1.10.4.

Table 4.7.1.10.4: Recirculation Rate Calculation Examples (based on BATHER LOAD) by Pool Type R&F

	Large Indoor Pool	Wave Pool	Activity Pool	Spray Pad	Kiddie Pool	Spa	Deep Diving Pool	Small Pool
Volume (gal.)	322,000	750,000	50,000	20,000	1,000	750	100,000	35,000
Average Depth (ft.)	7.33	4.98	3.00	1.00	1.00	1.50	16.00	5.00
Surf Area (ft ²)	5870.20	20120.5	2228.16	2673.80	133.69	66.84	835.56	935.83
Sq. Side (ft)	76.62	141.85	47.20	51.71	11.56	8.18	28.91	30.59
Factor 1 (bathers/ft ³)	0.007346	0.025	0.02	0.04	0.04	0.02667	0.003906	0.00945
Factor 2 (bathers/ft ³)	0.006011	0.00778	0.009445	0.04	0.04	0.02667	0.003906	0.00735
Factor 3 (bathers/ft ³)	0.003821	0.00504	0.009445	0.04	0.04	0.02667	0.003906	0.00655
Total Bathers	219.09	797.52	78.81	106.95	5.35	2.67	52.22	34.93
K	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34
gpm Q	1171	4261	421	571	29	14	279	187
Minimum Turnover	275	176	119	35	35	53	358	188
Raw Turnover	4.58	2.93	1.98	0.58	0.58	0.58	5.97	3.13
>100K gallons/ Large Pool								
Edge Load Factor	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Small Pool High Risk Factor	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Activity Pools Density/Line Factor	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
>90*/Hot Water High Temp. Factor	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Indoor Pools Env. Protect Factor	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Shower Required Bather Load Reduction	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Plain Pools Only; Apartment/Condo/Hotel Limited Use Factor	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Final Turnover (Hours)	5.8	1.61	0.99	0.22	0.44	0.22	7.56	4.16
w/ a Required Shower	6.67	1.86	1.14	0.25	0.5	0.25	8.69	4.78
Standard Table Values	4.0-5.0	1.5-2	1-1.5	0.25	0.50	25-5	6.0-8.0	5.0

When POOL recirculation rate recommendations are broken down to their essential elements, it is essentially about removing suspended matter (including microbial CONTAMINANTS) with the filters and effectively maintaining uniform FREE CHLORINE RESIDUAL at the proper pH. Both the FREE CHLORINE RESIDUAL and the microbial concentrations are a function of the number of BATHERS in a given volume of water. While it is not possible to always accurately predict the BATHER LOAD for a given POOL on a given day, it is generally possible to estimate the maximum number of BATHERS likely to be in any given type of POOL per unit surface area (since most BATHER have at least

their head above water most of the time and the primary activity in a POOL often dictates the comfort level in regards to BATHERS per unit surface area and hence the likelihood of BATHERS entering or leaving the POOL). After establishing a maximum sustainable bather load (MSBL) or maximum number of BATHERS expected in a POOL, it is possible to calculate the recommended flow of recirculated water necessary to be treated in order to handle the pathogen load and CHLORINE demand imparted by the BATHERS. An empirically-derived multiplier was used by PWTAG¹³² to convert the MSBL to the recommended recirculation rate. The empirical multiplier used in this code was derived independently using English units specifically for use in the U.S. The value of the U.S. multiplier is approximately 29% smaller than the PWTAG value using equivalent units because POOL design in the UK is more conservative than in the US.

4.7.1.10.4 Turnover Times

R&F

The recommended design TURNOVER time can then be calculated by dividing the volume by the recommended flow. This procedure can be performed for individual sections of a POOL or the entire POOL depending on the number of zones, which are based on depth of the water. Adjustments can then be made to this calculation to account for extraordinary conditions. For example, since a SPA has higher water temperature than a POOL a PATRON would be expected to sweat more, an indoor POOL might experience less contamination from pollen, dust, and rain than an equivalent outdoor POOL, and a POOL filled with diaper-age children would be considered an increased-risk POOL requiring more aggressive treatment. Aquatic facilities that enforce showering prior to POOL entry could reduce the organic load on the POOL by 35-60% with showers lasting only 17 seconds¹³³. The BATHER LOAD calculation based on surface area of the POOL has been proposed by PWTAG¹³⁴ in 1999 and has influenced the CODES proposed by the World Health Organization¹³⁵ and Australia¹³⁶. This approach has been adapted for use in the U.S. by slightly increasing the area recommended per BATHER in shallow waters and decreasing the area in deep POOLS to account for the intensity of deep water activities, the relatively low surface area to volume ratios of deep waters relative to shallow waters, the typically poorer mixing efficiency in deeper water, the increased amount of time typically spent underwater in deeper water, and the larger average size of BATHERS commonly found in deeper water. These values were empirically derived for the MAHC to match typical U.S. practices at the time of this writing and can be changed as necessary to achieve the desired water quality goals.

Effectively handling BATHER LOAD in terms of pathogen removals and CHLORINE demand is a paramount concern for which the above calculations should provide some science-based guidance. However, there are other factors that must be considered when

¹³² Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹³³ Keuten MGA et al. Definition and quantification of initial anthropogenic pollutant release in swimming pools. *Water Research*. 2012;46:3682-3692.

¹³⁴ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹³⁵ World Health Organization (WHO). *Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments*. 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808.

¹³⁶ NSW (New South Wales) Department of Health. Public Swimming Pool and Spa Pool Code of Practice. 2010. Available at: <http://www.health.nsw.gov.au/environment/publicpools/Pages/default.aspx>.

selecting a recirculation rate for an AQUATIC VENUE. For example, effectively distributing treated water to avoid dead spots recommends minimum water velocities to reach the POOL center and extremities. Similarly, effective surface skimming recommends adequate velocities at the surface of the POOL to remove floating CONTAMINANTS. Due to the kinetics of DISINFECTION and CHLORINE decay, CHLORINE must be replenished at some minimum intervals to maintain the recommended FREE CHLORINE RESIDUAL. For these reasons, MAHC Code Table 4.7.1.10 was developed to provide some maximum TURNOVER time limits for AQUATIC VENUES that are not dominantly influenced by BATHER LOAD to help ensure proper physical transport of CONTAMINANTS and DISINFECTANT. Values in this table are derived from historical practice and design experience worldwide. All AQUATIC VENUES must be designed to meet the lesser of the two maximum TURNOVER times.

4.7.1.10.5.1 Reuse Ratio

R&F

This section is intended to address those INTERACTIVE WATER PLAY VENUE designs that remove water from the INTERACTIVE WATER PLAY treatment tank by an AQUATIC FEATURE pump separate from the filtration system pump. The limit/ratio of INTERACTIVE WATER PLAY FEATURE water pump rate to the filtration system water pump rate is to acknowledge the typically high level of contaminants and turbidity introduced to the INTERACTIVE WATER PLAY treatment tank. The introduction and build-up of turbidity can exceed the rate at which it is removed by the filtration system which can result in interference with chemical DISINFECTION and UV treatment.

4.7.1.10.6 Flow Turndown System

R&F

The flow turndown system is intended to reduce energy consumption when AQUATIC VENUES are unoccupied without doing so at the expense of water quality. The turbidity goal of less than 0.5 NTU has been chosen by a number of U.S. state CODES (e.g., Florida) as well as the PWTAG¹³⁷ and WHO¹³⁸. The maximum turndown of 25% was selected to save energy while not necessarily compromising the ability of the RECIRCULATION SYSTEM to remove, treat, and return water to the center and other extremities of the POOL. Future research could determine that more aggressive turndown rates are acceptable. Some POOLS are already reportedly using the turndown system without a turbidimeter or precise flow rates. The intent of this section is to formalize a system for doing the turndown that does not compromise public health and SAFETY. Additional research in this area could identify innovative ways to optimize and improve this type of system. The likelihood of turbidimeters being cleaned and maintained is likely to be good because turbidimeters tend to give higher reading when not maintained properly.

AQUATIC VENUES designed above the minimum design STANDARDS would have the flexibility to increase system flows to maintain excellent water quality during periods of

¹³⁷ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹³⁸ World Health Organization (WHO). *Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments.* 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808.

peak activity. The flow turndown system is intended to reduce energy consumption when AQUATIC VENUES are unoccupied without doing so at the expense of water quality.

An electronic turbidity and RECIRCULATION SYSTEM flow feedback system would provide a quantifiable means of determining the water quality suitability if a facility desires to "turndown" the recirculation pumps to achieve a flow of up to 25% less than the minimum required recirculation flow rate when the AQUATIC VENUES is not occupied. The integration of feedback from both the flow meter and turbidimeter must be maintained for the VFD to be able to reduce the system flow rate below the level required to achieve the TURNOVER time requirement.

4.7.1.10.6.3 VFDs

R&F

Variable frequency drives (VFDs) offer the benefits of energy savings, operational flexibility, and in most cases the ability to automatically increase the pump flow as the filter clogs by interfacing the VFD with a flow meter (or potentially a filter effluent pressure transducer) by means of a proportional-integral-derivative (PID) controller. VFDs may also offer the added benefits of protecting piping, pumps, and valves. Energy savings and benefits will vary depending on the design of the system.

4.7.2 Filtration

System Design

R&F

The filtration system should be designed to remove physical CONTAMINANTS and maintain the clarity and appearance of the AQUATIC VENUE water. However, good clarity does not mean that water is microbiologically safe. With CHLORINE-tolerant human pathogens like *Cryptosporidium* becoming increasingly common in AQUATIC VENUES, effective filtration is a crucial process in controlling waterborne disease transmission and protecting public health. The filtration system of U.S. swimming POOLS has traditionally been designed to remove physical CONTAMINANTS and maintain the clarity and appearance of the AQUATIC VENUE water. Good clarity is important and will help prevent drowning and underwater collisions. Poor clarity can actually compromise the DISINFECTION process as well as leaving CHLORINE-tolerant pathogens suspended in the water for longer periods of time. As a future recommendation for discussion, filtration systems should be capable of removing *Cryptosporidium* OOCYSTS or an acceptable 4.5-micron surrogate particle with an efficiency of at least 90% (i.e., a minimum of 1 log reduction) in a single pass.

Water Quality

R&F

"If filtration is poor, water clarity will decline and drowning risks increase since swimmers in distress cannot be seen from the surface as well as needed. DISINFECTION will also be compromised, as particles associated with turbidity can surround microorganisms and shield them from the action of disinfectants. Particulate removal through coagulation and filtration is important for removing *Cryptosporidium* OOCYSTS

and *Giardia* cysts and some other protozoa that are resistant to chemical DISINFECTION.”¹³⁹

Pathogen Removal

R&F

One of the most significant recommended changes of the MAHC is changing the filtration system from one that only provides good clarity and appearance to one that efficiently removes waterborne human pathogens from the AQUATIC VENUE water. Water clarity is only an indicator of potential microbial contamination, but it is the most rapid indicator of possible high contamination levels. CHLORINE residual can be sufficiently high to kill indicator bacteria while leaving protozoa relatively unharmed and infective. Therefore, testing for indicator bacteria may not be useful as a measure of AQUATIC VENUE water quality, and testing for *Giardia* cysts and *Cryptosporidium* is very expensive and time-consuming. So, both measures are impractical as an operational tool for water quality measurement. *Cryptosporidium* is a widespread threat responsible for causing outbreaks in AQUATIC VENUES each year in the U.S.^{140,141} With CHLORINE-tolerant human pathogens like *Cryptosporidium* becoming increasingly common in AQUATIC VENUES, effective filtration is a crucial process in controlling waterborne disease transmission and protecting public health.^{142,143} Furthermore, an accidental fecal release could overwhelm the DISINFECTANT residual and leave physical removal as the only means of removing pathogens.¹⁴⁴ Filtration has been cited as the “critical step” for the removal of *Cryptosporidium*, *Giardia*, and free-living amoebae that can harbor opportunistic bacteria like *Legionella* and *Mycobacterium* species.¹⁴⁵

Cryptosporidium

R&F

Cryptosporidium is a CHLORINE-tolerant protozoan pathogen that causes the majority of waterborne disease outbreaks in swimming POOLS in the U.S. as shown in MAHC Annex Figure 4.7.2.1.¹⁴⁶ Surveillance for *Cryptosporidium* in the United States indicates that the reported incidence of infection has increased dramatically since 2004.¹⁴⁷ MAHC Annex Figures 4.7.2.2 and 4.7.2.3 demonstrate the increased incidence as well as the

¹³⁹ World Health Organization (WHO). Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808.

¹⁴⁰ Yoder JS et al. Cryptosporidiosis surveillance — United States, 2009–2010. MMWR Surveill Summ. 2012;61:1-12. Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6105a1.htm>

¹⁴¹ Hlavsa MC et al. Recreational water–associated disease outbreaks — United States, 2009–2010. MMWR Morb Mortal Wkly Rep. 2014;63(1):6-10. Available at <http://wwwdev.cdc.gov/healthywater/surveillance/rec-water-surveillance-reports.html>

¹⁴² World Health Organization (WHO). Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808.

¹⁴³ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁴⁴ World Health Organization (WHO). Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808.

¹⁴⁵ World Health Organization (WHO). Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808.

¹⁴⁶ Hlavsa MC et al. Recreational water–associated disease outbreaks — United States, 2009–2010. MMWR Morb Mortal Wkly Rep. 2014;63(1):6-10. Available at <http://wwwdev.cdc.gov/healthywater/surveillance/rec-water-surveillance-reports.html>

¹⁴⁷ Yoder JS and Beach MJ. *Cryptosporidium* surveillance and risk factors in the United States. Experimental Parasitology. 2010;124(1):31-39.

large number of outbreaks and total percentage of outbreaks of cryptosporidiosis associated with recreational water use since 2001, respectively.¹⁴⁸

FIGURE 4.7.2.1: Recreational water-associated outbreaks of gastroenteritis, by type of exposure and etiology — United States, 2001–2010¹⁴⁹ R&F

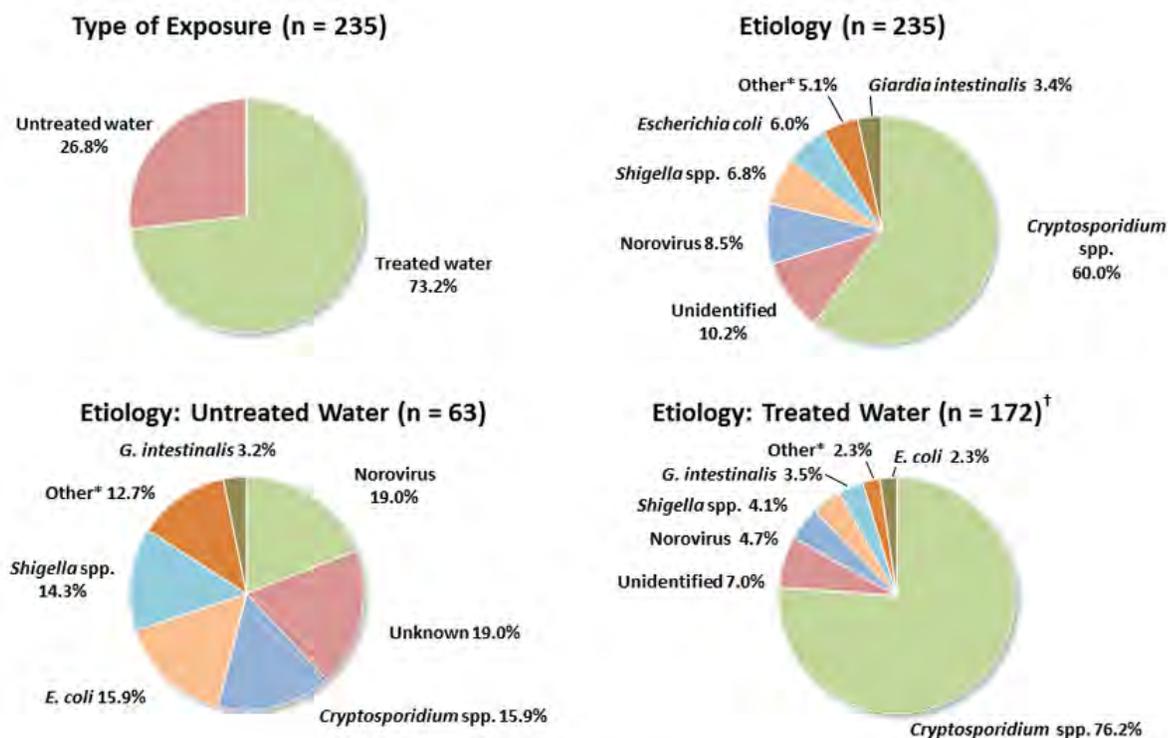
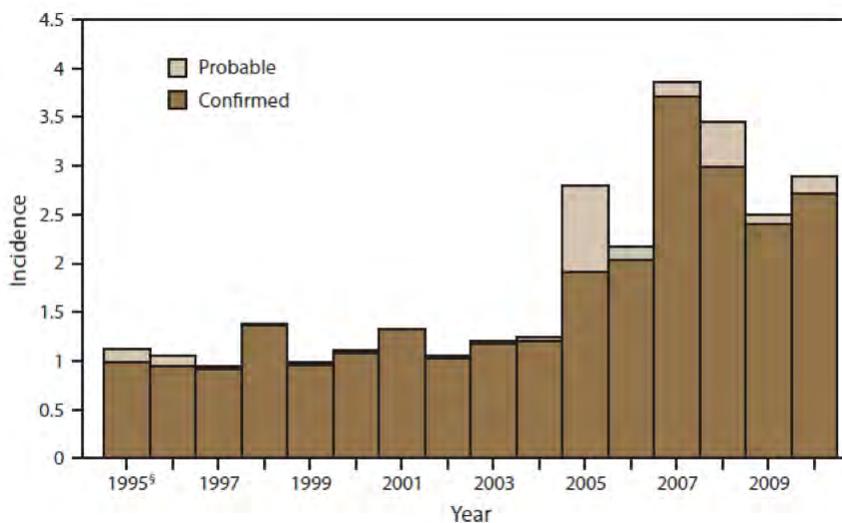


FIGURE 4.7.2.2: Incidence* of cryptosporidiosis, by year — National Notifiable Disease Surveillance System, United States, 1995–2010^{†150} R&F

¹⁴⁸ Yoder JS et al. Cryptosporidiosis surveillance — United States, 2009–2010. MMWR Surveill Summ. 2012;61:1-12. Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6105a1.htm>

¹⁴⁹ Hlavsa MC et al. Recreational water-associated disease outbreaks — United States, 2009–2010. MMWR Morb Mortal Wkly Rep. 2014;63(1):6-10. Available at <http://wwwdev.cdc.gov/healthywater/surveillance/rec-water-surveillance-reports.html>

¹⁵⁰ Yoder JS et al. Cryptosporidiosis surveillance — United States, 2009–2010. MMWR Surveill Summ. 2012;61:1-12. Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6105a1.htm>



* Per 100,000 population.

† N = 85,514.

§ First full year of national reporting.

3-Log Reduction

R&F

The current CT VALUES for a 3-log reduction in viability of fresh *Cryptosporidium* OOCYSTS with free CHLORINE are 10,400 mg/L·min (Iowa-isolate) and 15,300 mg/L·min (Maine-isolate) at pH 7.5.¹⁵¹ At a concentration of 1 mg/L, free CHLORINE can take more than 10 days to inactivate 99.9% of *Cryptosporidium* OOCYSTS (Ct=15,300 mg/L·min), but a many people are likely to be swimming in the AQUATIC VENUE during that 10-day period and risk being exposed to infective parasite concentrations. Infected individual may then return to the AQUATIC VENUE and/or visit other AQUATIC VENUES to perpetuate the spread of the parasite. Sand filters are commonly used and often serve as the only potential physical BARRIER to AQUATIC VENUE in U.S. AQUATIC VENUES, but sand filters without coagulant typically only remove about 25% of OOCYSTS per passage through the filter¹⁵². Based on the slow kinetics of CHLORINE inactivation of *Cryptosporidium*, the known inefficiency of sand filter to remove OOCYSTS, and the recent increased incidence of cryptosporidiosis in the U.S., additional measures appear necessary to effectively safeguard public health.

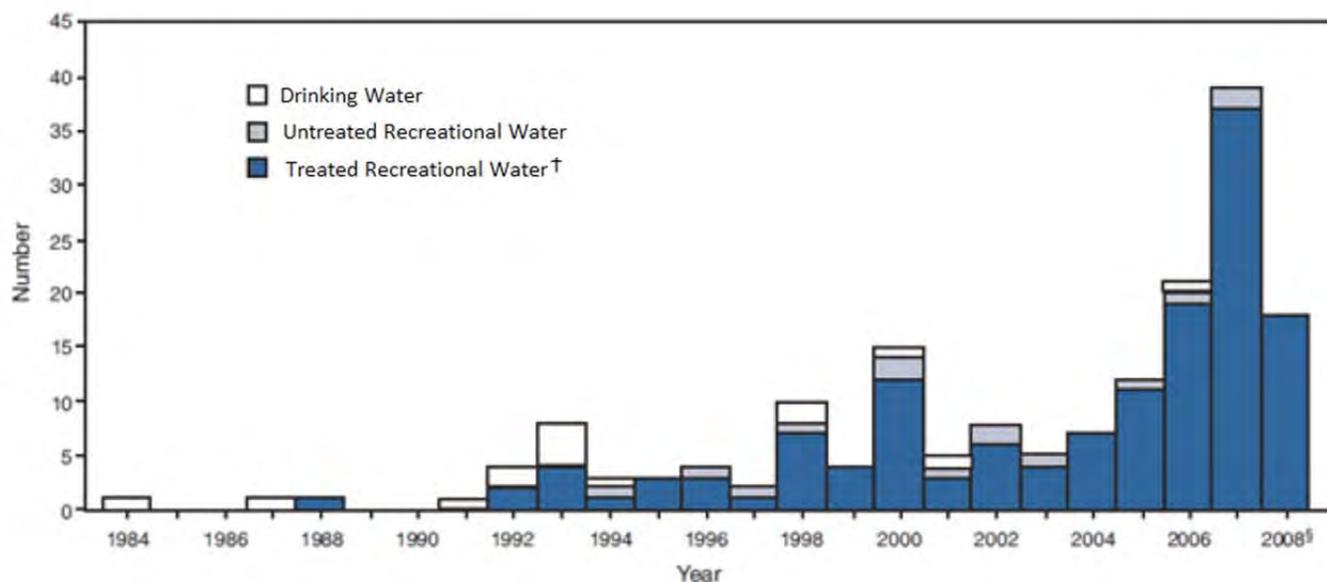
FIGURE 4.7.2.3: Number* of outbreaks of cryptosporidiosis associated with water, by water type — Waterborne Disease and Outbreak Surveillance System, United States, 1988–2008¹⁵³

R&F

¹⁵¹ Shields JM et al. Inactivation of *Cryptosporidium parvum* under chlorinated recreational water conditions. *Journal Water Health*. 2008;6(4):513-520.

¹⁵² Amburgey JE et al. Removal of *Cryptosporidium* and polystyrene microspheres from swimming pool water with sand, cartridge, and precoat filters. *J Water Health*. 2012;10(1):31-42.

¹⁵³ Yoder JS, Harral C, Beach MJ. Cryptosporidiosis surveillance---United States, 2006 - 2008. *MMWR Surveill Summ*. 2010;59(SS06):1-14.



* N = 172.

† Water that has undergone a treatment process (e.g., chlorination and filtration) to make it safe for recreation.

§ Data for 2007 and 2008 are provisional.

Explanation

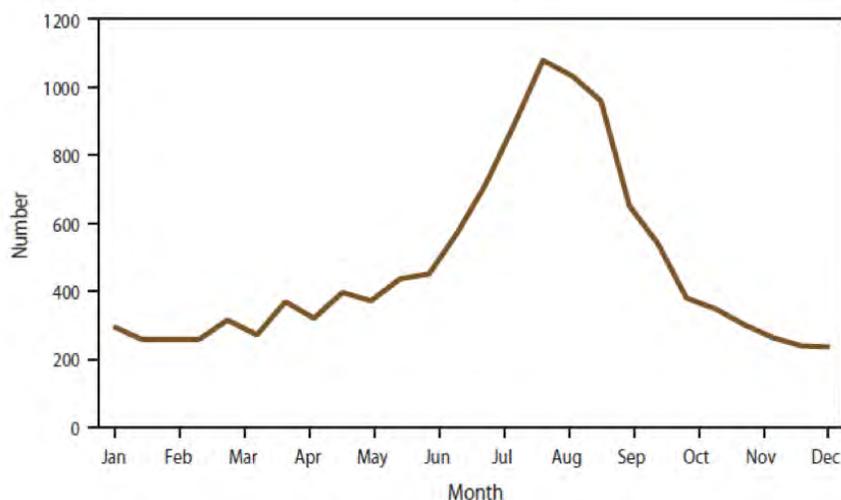
R&F

MAHC Annex Figure 4.7.2.3 (above) shows that the majority of outbreaks of cryptosporidiosis occur in “treated” recreational water. MAHC Annex Figure 4.7.2.4 (below) shows a dramatic increase in the number of cases of cryptosporidiosis during the warmer months of the year when outdoor public POOLS are normally open in the U.S. While it is difficult to assess the prevalence of protozoan parasites in public POOLS during normal operation, a study of 160 filter backwash water samples from Atlanta, GA showed that 13 (8.1%) were positive for *Giardia* or *Cryptosporidium* or both.¹⁵⁴

FIGURE 4.7.2.4: Number* of cryptosporidiosis case reports, by date of illness onset — National Notifiable Disease Surveillance System, United States, 2006–2009¹⁵⁵ R&F

¹⁵⁴ Shields JM, Gleim ER, and Beach MJ. Prevalence of *Cryptosporidium* spp. and *Giardia intestinalis* in swimming pools, Atlanta, Georgia. *Emerging Infectious Diseases*. 2008;14(6):948-950.

¹⁵⁵ Yoder JS, Harral C, Beach MJ. Cryptosporidiosis surveillance---United States, 2006 - 2008. *MMWR Surveill Summ*. 2010;59(SS06):1-14.



* N = 16,607; date of onset for 4,381 patients was unknown.

Review of Recreational Water Filtration Research Findings

R&F

Sand Filters

R&F

Sand filters often provide the only physical BARRIER to *Cryptosporidium* in U.S. AQUATIC VENUES, but sand filters meeting the recommendations of pre-existing POOL CODES typically only remove about 25% of OOCYSTS per passage through the filter¹⁵⁶. A quantitative risk assessment model of *Cryptosporidium* in AQUATIC VENUES confirmed there is a “significant public health risk”.¹⁵⁷ Some changes are necessary to effectively safeguard public health and will be discussed subsequently. Recent research in the U.S. and U.K. has shown that sand filters can remove greater than 99% of OOCYSTS per passage when a coagulant is added prior to filtration^{158,159}. The addition of coagulants to swimming POOL filters used to be common practice in the U.S. with rapid sand filters, but it fell out of favor as high-rate sand filters began to dominate the U.S. POOL market. The importance of coagulant addition to efficient pathogen removal in drinking water is well-documented and recommended in all U.S. surface water treatment facilities for drinking water production by the USEPA.^{160,161,162,163,164} The USEPA expects drinking

¹⁵⁶ Amburgey JE et al. Removal of *Cryptosporidium* and polystyrene microspheres from swimming pool water with sand, cartridge, and precoat filters. J Water Health. 2012;10(1):31-42.

¹⁵⁷ Pintar KD et al. A risk assessment model to evaluate the role of fecal contamination in recreational water on the incidence of cryptosporidiosis at the community level in Ontario. Risk Analysis. 2010;30:1:49-64.

¹⁵⁸ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁵⁹ Croll BT, Hayer CR, and Moss S. Simulated *Cryptosporidium* removal under swimming pool filtration conditions. Water Environment Journal. 2007;21:149-156.

¹⁶⁰ Letterman RD. Water Quality and Treatment. 1999. 5th Ed. McGraw-Hill, NY.

¹⁶¹ AWWA. Operational Control of Coagulation and Filtration Processes: AWWA Manual. 2010;M37, 3rd ed. American Water Works Association, Denver, CO. ISBN: 978-1-58321-801-3

¹⁶² Logsdon GS et al. Alternative filtration methods for removal of *Giardia* cysts and cyst models. Journal AWWA. 1981;73(2):111-118.

¹⁶³ Logsdon GS and Fox K. Getting your money's worth from filtration. Journal AWWA. 1982;74(5):249-256.

¹⁶⁴ USEPA. National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule

water treatment facilities to remove or inactivate a minimum of 99% (2 log) of *Cryptosporidium* OOCYSTS and up to 99.997% (4.5 log) for facilities treating source water with the highest concentration of OOCYSTS.²⁰ While more research and quantitative risk assessment models will be recommended to determine the safe level of removal in most AQUATIC VENUES, it is clear that the current removal rates of approximately 25% can lead to a significant number of outbreaks each year. Based on the research available for existing AQUATIC VENUE filtration technologies and risk models, a new minimum removal goal for *Cryptosporidium* removal by filters used in new and renovated swimming POOLS is recommended to be at least 90% (1 log) per single pass.

Filtration Systems

R&F

Multiple types of AQUATIC VENUE filtration systems have already been shown to achieve removals exceeding 99% depending on the filter design, water quality, and operational variables.

MAHC Annex Table 4.7.2.1 (below) contains a current summary of published research on *Cryptosporidium* or *Crypto*-sized microsphere removals via filtration in pilot-scale trials. Bench-scale results were not included due to concerns that the laboratory results might not be reproducible at pilot- or full-scale as has been observed in previous studies. MAHC Annex Table 4.7.2.1 is in sorted in order of increasing filter removal efficiency, and the data is roughly divided into three groupings (i.e., <90%, 90-99%, and >99% removal). Operating conditions falling into the first group would not be expected to reliably meet the new 90% (single pass) removal recommendation that is recommended for all new and renovated AQUATIC VENUES. Coagulant dosage, surface loading rate, and media depth can significantly impact filtration removals. Careful selection of both design and operating values is essential to achieving excellent pathogen removal with AQUATIC VENUE filters.

Table 4.7.2.1: Pilot-Scale Filter Removal Results for *Cryptosporidium* or *Crypto*-sized Microspheres in Pool Water¹⁶⁵ R&F

(Proposed Rule). 40 CFR Parts 141 and 142. Federal Register. 2003;68(154).

¹⁶⁵ Croll BT et al. Simulated *Cryptosporidium* removal under swimming pool filtration conditions. Water and Environment Journal. 2007;21:149-156.

Filter Type	Media Depth	Surface Loading Rate	Coagulant Type	Coagulant Dosage	Removal (%)
Sand	24 in.	10 gpm/ft ²	None	n/a	25-46%
Sand	24 in.	10 gpm/ft ²	PACl	0.014mg/L as A1	54.2%
Sand	24 in.	10 gpm/ft ²	PACl	0.006mg/Las A1	62.0-64.3%
Sand	24 in.	10 gpm/ft ²	Alum	0.06 mg/L as A1	65-68%
Sand	24 in.	10 gpm/ft ²	PACl	0.76-0.92 mg/L as A1	87.8-98.0%
Sand	24 in.	10 gpm/ft ²	PACl	0.065 mg/L as A1	91.5-97.3%
Sand	24 in.	10 gpm/ft ²	Alum	0.1 mg/L as A1	94-95%
Sand	24 in.	10 gpm/ft ²	Alum	0.3 mg/L as A1	96-97%
Sand	24 in.	10 gpm/ft ²	PACl	0.1 mg/L as A1	99.3-99.7%
Sand	24 in.	10 gpm/ft ²	PACl	0.21 mg/L as A1	99.6-99.8%

Filtration Products

R&F

At the time of this writing, the following filtration products are believed to be untested for *Cryptosporidium*/4.5-micron carboxylated microsphere removal in AQUATIC VENUE water:

- regenerative media filters,
- sand followed by cartridge (with 5-micron absolute or 1-micron nominal rating),
- Macrolite filter media,
- charged zeolite media,
- crushed-recycled glass filter media, and
- any others not listed in MAHC Annex Table 4.7.2.1.

Brief Historical Review of Water Filtration Practices for Aquatic Venues

R&F

1920's

R&F

In the U.S. in the 1920's, rapid sand filters on swimming pools were typically operated at 3-5 gpm/ft² with coagulation prior to filtration, but high-rate sand filters have largely replaced rapid sand filters because they operate at 15-20 gpm/ft² without coagulant.^{166,167} While high-rate sand filters are definitely cheaper and smaller, they are also less effective at removing *Cryptosporidium*-sized particles. The majority of U.S. drinking water treatment facilities still use rapid sand filters with coagulation and typically operate them at 3-5 gpm/ft². The USEPA, after an extensive review of peer-reviewed research, decided to give drinking water treatment facilities credit for removing 99% of *Cryptosporidium* oocysts for properly employing this technology (*i.e.*, *granular media filtration with coagulation prior to filtration*). Research has shown that high-rate

¹⁶⁶ Cary WH. Administration of Swimming Pool Standards in Detroit. Am. J. Public Health 1929;20(7):727-733.

¹⁶⁷ AJPH. Swimming Pools and Other Public Bathing Places: Standards for Design, Construction, Equipment, and Operation. Am. J. Public Health.1926;16:1186-1201.

AQUATIC VENUE sand filters can only consistently deliver 22 to 48% removal of *Cryptosporidium* oocysts and/or a microsphere surrogate without coagulation¹⁶⁸.

Increased Headloss Development Rates

R&F

Pressure Development

R&F

More efficient filtration of AQUATIC VENUE water will, in most cases, lead to higher rates of pressure development in filters and more frequent backwashing of filters. The smaller the pores in the filter media at the surface of the filter, the more rapidly pressure would be expected to increase. Fortunately, there are a number of options available to design engineers that could reduce the rate of pressure development. These options include the use of more uniformly graded filter media, skimming fines from filter media prior to startup, more efficient backwashing of filters, lowering the flow rate per unit surface area, and the use of two types of filter media in filters.

4.7.2.2 Granular Media Filters

R&F

4.7.2.2.1 General

R&F

Design Tip

R&F

Design Tip: When a single pump feeds two filters at 10 gpm/ft², redirecting the entire flow through one filter into the backwash line of the other should result in a backwash rate of approximately 20 gpm/ft². The backwash water would be unfiltered water that would have to be plumbed to bypass the filter. With three filters, it would be possible to redirect water from two filters into the backwash influent pipe of the third filter to provide clean backwash water.

4.7.2.2.1.3 Listed

R&F

Equipment testing of filters to industry STANDARDS is critically important, but it is only one aspect of performance. A filter certified with the hydraulic capability to pass water at 20 gpm/ft² does not mean this filter should be operated at 20 gpm/ft². Granular media filters perform better at removing particles and microbes at lower filter loading rates (all other factors equal), and this finding has been repeatedly observed in practice and can be explained theoretically. Filters might need to be held to higher STANDARDS of performance in terms of water quality than the current industry STANDARD.

Manufacturers and testing laboratories might need to work together to produce more effective filters and new testing procedures. The maximum filtration rate of 15 gpm/ft² is the first step toward a change in filter design STANDARDS aimed at improving microbial removal and preventing recreational water illnesses. The MAHC is intentionally more restrictive than the current NSF Standard 50 flow requirements.

4.7.2.2.2 Filter Location and Spacing

R&F

¹⁶⁸ Amburgey JE et al. Removal of *Cryptosporidium* and polystyrene microspheres from swimming pool water with sand, cartridge, and precoat filters. J Water Health. 2012;10(1):31-42.

4.7.2.1.2.1 Required**R&F**

Sufficient floor space should be available to accommodate installation of additional filters to increase the original filtration surface area by up to 50% should it be recommended by future regulations or to meet current water quality STANDARDS. This is part of the hydraulic flexibility recommendation of newly constructed POOLS. The idea is to recommend space for additional filters should they become necessary at some point in the future. The 'extra' space could be utilized to make EQUIPMENT ROOMS safer and more functional.

A port and ample space for easy removal of filter media is also recommended. Filter media might be changed every 5 years. This process could be exceedingly difficult if filters are not designed with a port for this purpose or if the filters are installed without proper clearance to access the media removal port.

4.7.2.2.3 Filtration and Backwashing Rates**R&F****4.7.2.2.3.1 Operate****R&F**

High-rate granular media filters shall be designed to operate at no more than 15 gpm/ft² of filter surface. The minimum depth of filter media above the under-drains (or laterals) shall be set by the filter manufacturer. Filters with bed depths less than 15" shall operate at no greater than 12 gpm/ft² of filter surface area. A minimum bed depth of 15" is required for flow rates greater than 12 gpm/ft² to a maximum of 15 gpm/ft². -- Allowable filter rate is directly related to bed depth.

The granular media filter system should be designed to backwash each filter at a rate of at least 15 gallons per minute per square foot (48.9 m/h) of filter bed surface area, unless explicitly prohibited by the filter manufacturer. Specially graded filter media should be recommended in filter systems backwashing at less than 20 gpm/ft² (48.9 m/h) to be able to expand the bed at least 20% above the fixed bed height at the design backwash flow rate, which is subject to approval by the local authority. Filtration and backwashing at the same flow rate is likely to lead to poor performance of both processes. Backwashing at double the filtration rate is not all that complicated with a 3-filter system, where the flow of two filters is used to backwash the third. Further, backwashing with unfiltered water is possible in a 2-filter system by backwashing with the entire recirculation flow through each filter individually. Variable drive pumping systems and accurate flow meters also contribute to the likelihood of successful backwashing as well as effective filtration.

Effective Filtration**R&F**

Filtration at 10 gpm/ft² is really pushing the envelope for attaining effective filtration and would not be recommended for a municipal drinking water system using sand filters due to doubts about the ability of such a filter to remove particulate CONTAMINANTS reliably. There are instances where multi-media deep bed filters or mono-medium filters with large diameter anthracite and 6 foot deep or greater beds of media are used, such as those owned and operated by the Los Angeles Department of Water and Power.

Effective filtration of drinking water at high filtration rates recommends careful and exact management of coagulation. Whereas filtration rates are not explicitly addressed in much of the research on water filtration, the experience of researchers, regulators, and consultants is that high rate filtration recommends extra attention and talent. For example, over 3 decades ago the State of California allowed the Contra Costa Water District to operate filters at 10 gpm/ft² but other water utilities were not allowed to do this. The exception was permitted because of the design and the high level of operating capability at the plant where the high rate was used. Operation at very high rates either causes very rapid increases of head loss in sand filters [water utility experience resulted in the conclusion that operating sand filters at rates above 3 or 4 gpm/ft² was impractical] or very little particle removal occurs as water passes through the sand bed, thus enabling filters to operate for a long time at high rates. For this reason following World War II, the use of anthracite and sand filters became the norm for filters designed to operate at 4 or 5 gpm/ft² or higher. Finally, in the 1980s, workers in Los Angeles showed that a deep [6 ft] filter with 1.5 mm effective size anthracite media could effectively filter water at rates of close to 15 gpm/ft². However, for very high rates of filtration to be effective, pretreatment has to be excellent, with proper pH and coagulant dosage, probably use of polymer, and in some cases, use of a pre-oxidant to improve filter performance. This is well understood by filter designers and professors who specialize in water filtration. Articles published on the Los Angeles work done by James Montgomery Engineers showed the importance of proper pretreatment. Papers written by experts on filtration have noted the importance of effective pretreatment [including proper coagulation] for dependable filter performance, and those writers were focused on rates employed in municipal filtration plants (e.g. 3 to 10 gpm/ft²). As filtration rate increases, water velocity through the pores in the sand bed increases, making it more difficult for particles to attach to sand grains and remain in the bed instead of being pushed on through the bed and into filter effluent. When filters do not work effectively for pathogen removal, the burden is put on DISINFECTION to control the pathogens. For *Cryptosporidium*, the DISINFECTION approach that is typically most cost-effective is UV, so a very high rate filter may need to be followed by UV for pathogen inactivation, and the very high rate filters would just have to clarify the water sufficiently that there is no interference from particulate CONTAMINANTS with the UV inactivation process.

4.7.2.2.3.2

Backwash System Design

R&F

For a granular media filter system to be able to backwash at a rate of at least 15 gallons per minute per square foot (48.9 m/h) of filter bed surface area, the pump(s), pipes, and filters must be designed accordingly. As many professionals have sought to improve water quality by decreasing the filtration rate to values lower than 15 gpm/ft², they have sometimes failed to recognize that while lowering the filtration rate may generally produce a positive change in performance, a similarly lower backwash rate could lead to a total filtration system failure. In cases where a backwash rate of 15 gpm/ft² is explicitly prohibited by the filter manufacturer, the filter may still be used provided that specially graded filter media is installed that will expand to a minimum of 20% bed expansion at the specified backwash flow rate. Viewing windows are highly recommended in all filters since they will allow direct observation of the bed expansion during backwashing, cleanliness of the media and backwash water, and the depth of the sand in the filter.

Croll and coworkers¹⁶⁹ used a backwashing rate of 25 gpm/ft² (61 m/h) to achieve 25% bed expansion of their filter.

WHO Recommends

R&F

The WHO recommends a backwash rate of 15-17 gpm/ft² (37-42 m/h) for sand filters, but the media specifications are not given nor is it clear whether or not air-scour is expected prior to backwashing.¹⁷⁰ Backwashing swimming POOL sand filters with air scour is common in the UK and elsewhere.^{171,172} It has also been reported that air-scour washed AQUATIC VENUE filters are more efficient than filters washed by water only.¹⁷³ It is reasonable that lower backwashing rates would be used for water backwash when following air-scour since the air-scour dislodges most of the particles attached to the media grains (as opposed to relying on the sheer force of the water passing over the surface of the particles). It is not feasible to operate sand filters in drinking water treatment plants without an auxiliary backwash system such as air scour.¹⁷⁴ The practice of operating AQUATIC VENUE and filters (that were not using coagulation) without air scour has been STANDARD practice in the U.S. for many years, which has seen mixed results ranging from no problems to total system failures requiring replacement of all filter media. PWTAG recommends air-scouring filters at 32 m/h (at 0.35 bar).¹⁷⁵

Polyphosphate Products

R&F

Polyphosphate products are sometimes used to sequester metals in POOLS, but this practice is not recommended when granular media filters are used because polyphosphate is an effective particle dispersant that can reduce the removal efficiency

Filter Bed Expansion

R&F

Sufficient freeboard (or space between the top of the media and the backwash overflow) to allow for a minimum of 35% filter bed expansion during backwashing adds a factor of SAFETY when the target bed expansion is 20% to prevent the washout of filter media during backwashing.

The regions underneath the lateral underdrains in granular media filters can become stagnant when filled with sand or gravel, which can lead to low disinfectant residuals and ultimately biofilm growth. Filling this area with concrete at the time of installation may prevent this potential problem.¹⁷⁶ It is fundamentally difficult to suspend (i.e.,

¹⁶⁹ Croll BT et al. . Simulated *Cryptosporidium* removal under swimming pool filtration conditions. *Water Environ J.* 2007;21:149-156.

¹⁷⁰ World Health Organization (WHO). *Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments.* 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808

¹⁷¹ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁷² World Health Organization (WHO). *Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments.* 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808

¹⁷³ Neveu A et al. Evaluation of Operation and performance of Swimming Pool filtration Plants. *Francaisd'Hydrologie.* 1988;19:2:203-213.

¹⁷⁴ Hendricks D. *Water Treatment Unit Processes, Physical and Chemical.* 2006. CRC Press (Taylor & Francis Group), Boca Raton, FL. ISBN: 0824706951.

¹⁷⁵ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁷⁶ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for*

fluidize) and hence clean filter media or gravel that is below the level where the backwash water enters the filter.

4.7.2.2.4 Filter Media Depth Requirement

R&F

The performance of high-rate granular media filters at removing pathogens and particles is contingent upon the depth of the filter media (as shown in MAHC Annex Table 4.7.2.1), especially at rates of 15 gpm/ft² (36.7 m/h), which is why these filters recommend at least 24 inches (0.61 m) of filter media. The WHO recommends filtration at 10-12 gpm/ft² (25-30 m/h) for sand filters while the PWTAG recommends 4-10 gpm/ft² (10-25 m/h) as the maximum filtration rate for all non-domestic POOLS using sand filters.^{177,178} The STANDARD sand filter bed depth typically varies from 0.55 to 1 m (22 to 39 inches) in the UK.¹⁷⁹

4.7.2.1.4.1 Minimum Depth

R&F

For swimming POOL filters with less than 24 inches of media between the top of the laterals and the top of the filter bed, lower filtration rates (e.g., 10 gpm/ft² (24.4 m/h) are recommended to efficiently remove particles and pathogens. Improvements in particle removal with decreasing filtration rates have been documented.¹⁸⁰ Drinking water treatment facilities typically limit filtration to less than 4 gpm/ft², which is similar to the filtration rates recommended in AQUATIC VENUES in the 1920's.^{181,182} The minimum depth of sand in POOL filters was 36-inches in 1926.¹⁸³ Sand filters are typically designed in drinking water treatment for an L/d ratio of 1000 or greater, where L is the depth of the media and d is the diameter of the media grain.¹⁸⁴ For example, a 0.6 mm effective size sand would recommend a minimum 0.6 m (23.6-inches) bed depth, and a 12-inch (0.3 m) deep sand bed with 0.5 mm grains would have an L/d of only 610.

The minimum depth of filter media above the underdrains (or laterals) is recommended be 24 inches (0.61 m) or greater with sufficient freeboard (or space between the top of the media and the backwash overflow) to allow for a minimum of 35% filter bed expansion during backwashing. Sand or other approved granular media should be carefully graded to ensure fluidization of the entire filter bed during backwashing.

A design backwash rate of at least 30% higher than the minimum fluidization velocity of the d90 size of the media in water at the larger of 86° F (30° C) or the maximum

Pools and Spas, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁷⁷ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁷⁸ World Health Organization (WHO). *Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments.* 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808

¹⁷⁹ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁸⁰ Gregory R. Bench-marking Pool Water Treatment for Coping with *Cryptosporidium*. *Journal of Environmental Health Research.* 2002;1(1):11-18.

¹⁸¹ Logsdon GS et al. Alternative filtration methods for removal of Giardia cysts and cyst models. *Journal AWWA.* 1981;73(2):111-118.

¹⁸² Logsdon GS and Fox K. Getting your money's worth from filtration. *Journal AWWA.* 1982;74(5):249-256.

¹⁸³ Logsdon GS and Fox K. Getting your money's worth from filtration. *Journal AWWA.* 1982;74(5):249-256.

¹⁸⁴ Cleasby JL and Logsdon GS. Chapter 8: Granular Bed and Precoat Filtration. In *Water Quality and Treatment, 5th Ed.* McGraw Hill, Inc. NY:1999. ISBN: 0070016593.

anticipated operating temperature is recommended. A backwash rate higher than the minimum could be necessary to effectively clean the media during backwashing. Variations in the media type, density, water temperature, effective size, or uniformity coefficient may cause changes in the recommended backwash flow rate and/or bed expansion, which should be subject to approval by the local authority provided hydraulic justification by the design engineer.

Sand or other approved granular media should be carefully graded to ensure fluidization of the entire filter bed during backwashing. The specifications of POOL filter sand (or lack thereof) can lead to filter media being installed that cannot be effectively cleaned during backwashing. Sand that cannot be properly cleaned can lead to filter failures and/or biofilms in the bottom of a filter. Researchers have found nematodes, rotifers, ciliates, zooflagellates, amoebic trophozoites and cysts, as well as bacterial masses in the backwash water of swimming POOL sand filters.¹⁸⁵ A design backwash rate of at least 30% higher than the minimum fluidization velocity of the d90 size of the media in water at the larger of 86° F (30° C) or the maximum anticipated operating temperature is recommended, but a backwash rate higher than the minimum could be necessary to effectively clean the media during backwashing. These backwashing recommendations are based on drinking water treatment practice.¹⁸⁶ For a sample of AQUATIC VENUE filter sand examined at UNC Charlotte, the d90 size (i.e., 90% of the grains smaller than this diameter) of the media was estimated from the sieve analysis results in MAHC Annex Figure 4.7.2.1.4.1 to be 1.06 mm. The calculated minimum fluidization velocity of this sized sand grain in water at 30° C was calculated to be 16.7 gpm/ft². Since this backwash velocity would be expected to leave approximately 10% of the grains in the filter that were larger than the d90 unfluidized, common practice is to recommend a backwashing rate 30% greater than this minimum value (or 21.7 gpm/ft²). The recommended backwash flow for this media by Kawamura¹⁸⁷ was graphically estimated to be 20.9 gpm/ft² at 20° C. This is the rationale for requiring at least 15 gpm/ft² backwashing rate of all swimming POOL sand filters.

To ensure compatibility with the minimum recommended backwashing rate of 15 gpm/ft² (48.9 m/h), filter sand should pass through a number 20 U.S. STANDARD sieve or equivalent (i.e., all sand grains should be smaller than approximately 0.85 mm). While this recommendation of “#20 Silica sand” is common in swimming POOL manuals and by filter manufacturers, it does not appear to be representative of the actual sand that might be installed. Sieve analyses of two brands of commercially available “POOL filter sand” are provided in MAHC Annex Figures 4.7.2.1.4.1 and 4.7.2.1.4.2. Sand can also be specified by an effective size (E.S.) of 0.45 mm with a uniformity coefficient (U.C.) of less than or equal to 1.45, which is roughly equivalent to a 20/40 mesh sand. A 20/40 mesh sand would pass through a #20 (0.85 mm sieve) and be retained on a #40 (0.42 mm) sieve. In order to reduce the rate of headloss accumulation at the top of the filter

¹⁸⁵ Lyons TB and Kapur R. Limax Amoebae in Public Swimming Pools of Albany, Schenectady, and Rensselaer Counties, New York: Their Concentration, Correlations, and Significance. *Applied and Environmental Microbiology*. 1977;33(3):551-555.

¹⁸⁶ Cleasby JL and Logsdon GS. Chapter 8: Granular Bed and Precoat Filtration. In *Water Quality and Treatment*, 5th Ed. McGraw Hill, Inc. NY:1999. ISBN: 0070016593.

¹⁸⁷ Kawamura, S. *Integrated Design and Operation of Water Treatment Facilities*. 2000. John Wiley and Sons, Inc., NY.

bed (and the frequency of backwashing), a 20/30 mesh sand could be specified where the smallest grains at the top of the filter would be approximately 0.60 mm (30 mesh) instead of 0.42 mm (40 mesh).

Figure 4.7.2.1.4.1: Grain Size Distribution of Pool Filter Sand

R&F

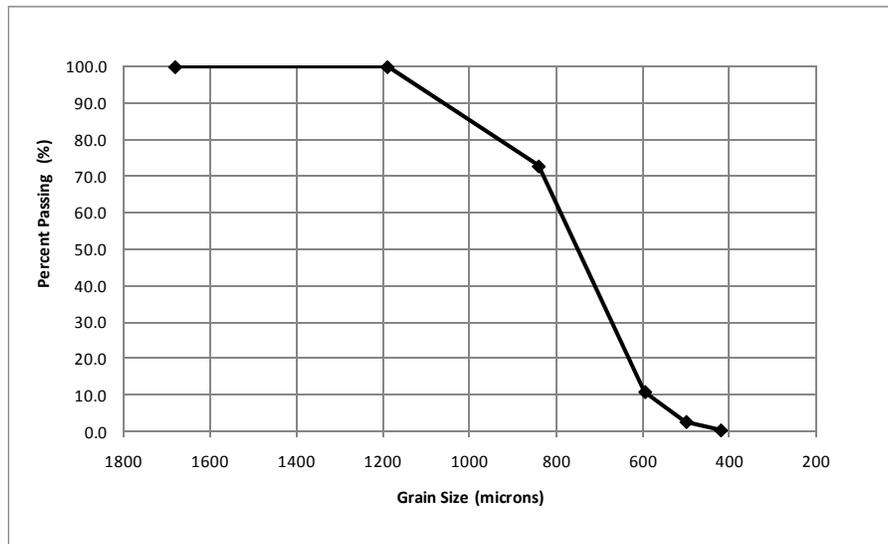
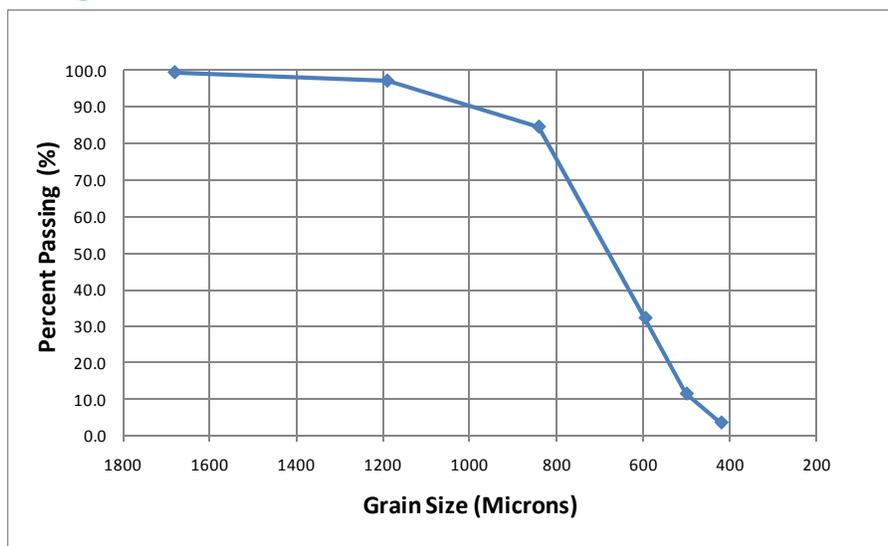


Figure 4.7.2.1.4.2: Grain Size Distribution of Pool Filter Sand

R&F



The depth of the expanded bed during backwashing should be at least 20% greater than the depth of the fixed bed after backwashing.

Experiments to determine experimentally the backwashing rates recommended to fluidize a bed of POOL filter sand in 3-inch and 6-inch diameter clear PVC filter columns based on visual observation were conducted. Fluidization is somewhat subjective when

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observed visually because sand grains could be moving sluggishly prior to fluidization and because the smaller grains at the top of the filter will fluidize long before the larger grains at the bottom. For this reason, bed expansion was measured and recorded along with visual observations of when the bed actually fluidized. Fluidization was visually observed to occur between 20 and 23 gpm/ft², which coincided with 19-23% bed expansion in both sized columns for the unaltered commercial filter media at 20° C. Expansion data from the 3" diameter filter column is shown in MAHC Annex Table 4.7.2.1.4.1. The 20/30 mesh fraction of the same filter media was examined under the same conditions, and the experimental results are provided in MAHC Annex Table 4.7.2.1.4.2. The media was observed to be fully fluidized at 19.9 gpm/ft² with a bed expansion of 21.8% at 20° C. Calculations based on Cleasby and Logsdon¹⁸⁸ indicate that filter backwashing rates should increase by approximately 18% for this media as the temperature is increased from 20° to 30° C due to changes in the viscosity of water with temperature. Fluidization can be somewhat complicated to estimate, but filter bed expansion can be easily measured in the field with granular media filters that use viewing windows. Furthermore, a model exists that can be used to calculate filter bed expansion of sand in a filter during backwashing.¹⁸⁹ The preceding model tends to be sensitive to fixed bed porosity, but using a value of 42% porosity with a sphericity of 0.85 and density of 2.65 g/cm³ yielded a bed expansion of 22.7% at 20 gpm for water at 30° C. This is the rationale for requiring the depth of the expanded bed during backwashing being at least 20% greater than the depth of the fixed bed. PWTAG recommends 15-25% bed expansion following air scouring at 32 m/h (at 0.35 bar).¹⁹⁰ In a study funded by PWTAG, researchers used a backwashing rate of 25 gpm/ft² (61 m/h) to achieve 25% bed expansion of their filters.¹⁹¹ Variations in the media type, density, water temperature, effective size, or uniformity coefficient may cause changes in the recommended backwash flow rate and/or bed expansion, which should be subject to approval by the local authority provided hydraulic justification by the design engineer.

Table 4.7.2.1.4.1: Pool Filter Sand at 20° C**R&F**

¹⁸⁸ Cleasby JL and Logsdon GS. Chapter 8: Granular Bed and Precoat Filtration. In *Water Quality and Treatment*, 5th Ed. McGraw Hill, Inc. NY:1999. ISBN: 0070016593.

¹⁸⁹ Dharmarajah AH and Cleasby JL. Predicting the Expansion Behavior of Filter Media. *Journ. AWWA*. 1986;78(12):66-76.

¹⁹⁰ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas*, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁹¹ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas*, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.

Backwash Flow (gpm/ft ²)	Bed Expansion (%)
12.4	3.6
16.3	11.4
18.5	16.3
20.3	19.3
22.1	22.5

Table 4.7.2.1.4.2: Pool Filter Sand Sieved 20/30 mesh at 20° C **R&F**

Backwash Flow (gpm/ft ²)	Bed Expansion (%)
12.2	4.8
15.8	13.0
17.9	17.4
19.9	21.8
21.5	25.6
23.9	31.2

4.7.2.2.5 Differential Pressure Measurement **R&F**

4.7.2.2.6 Coagulant Injection Equipment **R&F**

4.7.2.2.6.1 Installed **R&F**

To enhance filter performance, a coagulant feed system, when used, should be installed with an injection point located before the filters and, for pressure filters, on the suction side of the recirculation pump(s) capable of delivering a variable dose of a coagulant (e.g., polyaluminum chloride or a POOL clarifier product) to enhance filter performance. Pumps should be properly sized to allow for continuous delivery of the recommended dosage of the selected coagulant. Products used to enhance filter performance should be used according to the manufacturers' recommendations. The coagulant feed system should consist of a pump, supply reservoir, tubing, ISOLATION valve, and BACKFLOW prevention device. Sand filters used as prefilters for membranes or cartridge filters with 1-micron nominal or 5-micron absolute size ratings or less should not be recommended to have coagulant injection equipment. Specialized granular filter media capable of removing *Cryptosporidium* OOCYSTS or an acceptable 4.5-micron surrogate particle with

an efficiency of at least 90% (i.e., a minimum of 1 log reduction) without coagulation should not be recommended to provide coagulant injection equipment, but this media should be replaced or reconditioned as recommended to sustain the minimum recommended particle removal efficiency stated above. Sand filters located ahead of a UV or ozone DISINFECTION system may be excluded from supplying coagulation equipment with the approval of the local authorities. Local authorities should consider the efficiency of the supplemental DISINFECTION process for *Cryptosporidium* inactivation but should also consider that a side-stream system does not have any effect on the *Cryptosporidium* OOCYSTS that bypass the system on each TURNOVER. For example, a UV system that is 99.999% effective at inactivating *Cryptosporidium* that only treats half of the recirculated water flow is on average only 50% effective (per pass) because all of the *Cryptosporidium* in the bypass stream remain unaffected by the UV.

Coagulation is the key to effective granular media filtration, which has long been recognized in the drinking water industry.^{192,193,194,195,196} Operation of granular media filters without coagulation is not permitted by USEPA regulations for drinking water treatment, with the exception of slow sand filters. Thus, if pathogen removal is a goal of water filtration for swimming POOL sand filters, coagulation would be essential. This is the rationale for recommending future consideration of coagulation in swimming POOLS. A coagulant feed system should be installed with an injection point located ahead of the filters to facilitate particle removal by filtration (instead of settling to the bottom of the POOL), and injection ahead of the recirculation pump(s) will provide mixing to evenly distribute the coagulant among the particles. A variable dose of a coagulant (e.g., polyaluminum chloride, or POOL clarifier) is recommended because coagulant dosages may vary with BATHER LOAD. Products used to enhance filter performance should be used according to the manufacturers' recommendations since overfeed or underfeed of coagulants is known to impair performance.

Although polyaluminum chloride (PACl) is not a widely used coagulant in the U.S. at present, it has been used extensively abroad.^{197,198} However, recommended dosages abroad may not be optimized for pathogen removal. PWTAG recommends a polyaluminum chloride dosage of 0.005 mg/L as Al, but research has shown that 0.05 mg/L is recommended to exceed 90% removal and 0.21 mg/L or higher could be optimal with filters operated based on U.K. STANDARDS.¹⁹⁹

¹⁹² Letterman RD. Water Quality and Treatment. 1999. 5th Ed. McGraw-Hill, NY.

¹⁹³ AWWA. Operational Control of Coagulation and Filtration Processes: AWWA Manual. 2010;M37, 3rd ed. American

Water Works Association, Denver, CO. ISBN: 978-1-58321-801-3

¹⁹⁴ Logsdon GS and Fox K. Getting your money's worth from filtration. Journal AWWA. 1982;74(5):249-256.

¹⁹⁵ USEPA. National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule (Proposed Rule). 40 CFR Parts 141 and 142. Federal Register. 2003;68(154).

¹⁹⁶ Logsdon GS. *Water Filtration Practices: Including Slow Sand Filters and Precoat Filtration*. 2008. American Water Works Association, Denver, CO. ISBN: 9781583215951.

¹⁹⁷ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed.* 2009. Micropress Printers, Ltd. ISBN: 0951700766.

¹⁹⁸ World Health Organization (WHO). *Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments*. 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808

¹⁹⁹ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for*

New Challenges: The Impact of Coagulation on Backwashing R&F

Coagulation is likely to make cleaning of sand filters more challenging. Drinking water treatment facilities in the U.S. employ auxiliary backwash systems such as air-scour to improve the cleaning process. Using water alone for backwashing has not been found to be effective for media cleaning in drinking water treatment applications.²⁰⁰ Air scour systems are common in European AQUATIC VENUE filters and should be investigated further in the U.S. More frequent backwashing is recommended with water-only backwash, and the clean-bed headloss (pressure) should be recorded after each backwash to detect early signs of ineffective backwashing and prevent filter system failures.

Initial Headloss and Headloss Accumulation Rate R&F

Increased headloss (or pressure buildup) in filters is expected with coagulation as particles are likely to be removed faster (more efficiently) and closer to the top of the filter thereby clogging the top of the filter more quickly. This is actually a sign that the coagulation/filtration system is working effectively. The initial headloss after backwashing should remain relatively constant however. Coagulants have been used successfully in the U.S. in the past and are currently being used in POOLS abroad.^{201,202,203,204} In systems not properly designed to backwash with filter effluent from other filters, the coagulant feed system should not be operated during backwashing so as to prevent introduction of coagulant into the backwash water.

4.7.2.3 Precoat Filters R&F

4.7.2.3.1 General R&F

4.7.2.3.2 Filtration Rates R&F

The design filtration rate of 2.0 gallons per minute per square foot (4.9 m/h) might be overly conservative and is the same upper limit on filtration rate typically used in drinking water treatment applications.²⁰⁵ However, drinking water applications typically use finer grades of precoat media at application rates of 0.2 lbs/ft² (1 Kg/m²).³² Lange and coworkers²⁰⁶ have used filtration rates up to 4 gpm/ft² (9.8 m/h) with no adverse effect on *Giardia* cyst removal although the removal of turbidity and bacteria were decreased. Ongerth and Hutton²⁰⁷ actually found better removals at 2 gpm/ft² than at 1

Pools and Spas, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.

²⁰⁰ Hendricks D. *Water Treatment Unit Processes, Physical and Chemical*. 2006. CRC Press (Taylor & Francis Group), Boca Raton, FL. ISBN: 0824706951.

²⁰¹ Pool Water Treatment Advisory Group (PWTAG). *Swimming Pool Water: Treatment and Quality Standards for Pools and Spas*, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.

²⁰² Logsdon GS et al. Alternative filtration methods for removal of *Giardia* cysts and cyst models. *Journal AWWA*. 1981;73(2):111-118.

²⁰³ Logsdon GS and Fox K. Getting your money's worth from filtration. *Journal AWWA*. 1982;74(5):249-256.

²⁰⁴ DIN. Treatment and Disinfection of Water Used in Bathing Facilities, Part 1: General Requirements. 1997. Ref. No. 19643-1.

²⁰⁵ Logsdon GS. *Water Filtration Practices: Including Slow Sand Filters and Precoat Filtration*. 2008. American Water Works Association, Denver, CO. ISBN: 9781583215951.

²⁰⁶ Lange KP et al. Diatomaceous Earth Filtration of *Giardia* Cysts and Other Substances. *Journal AWWA*. 1986;78(1):76-84.

²⁰⁷ Ongerth JE and Hutton PE. Testing of Diatomaceous Earth Filtration for Removal of *Cryptosporidium*

gpm/ft² for *Cryptosporidium* OOCYSTS under drinking water treatment conditions (i.e., 0.2 lbs/ft² of DE with body-feed).

4.7.2.3.3 Precoat Media Introduction System R&F

4.7.2.3.3.1 Precoat Process R&F

The precoat process shall follow the manufacturer's recommendations and requirements of NSF/ANSI Standard 50.

Separation Tank R&F

Precoat filter media has the potential to settle out of suspension in sewer pipes depending on the flow velocities, which could lead to fouling or clogging of sewer pipes. Local authorities may recommend removal of precoat media prior to discharge in sewer systems so POOL operators should check the AHJ.

4.7.2.3.4 Continuous Filter Media Feed Equipment R&F

Filters performance can be significantly impacted by the selection of the precoat filter media, which could alter water clarity, pathogen removal, and cycle length. Multiple grades of precoat media are available in the marketplace. Precoat media can be specified by median particle size of the media or by permeability of the media.³²

4.7.2.4 Cartridge Filters R&F

4.7.2.4.1 Listed R&F

Cartridge filters have not been demonstrated to remove pathogens like *Cryptosporidium* efficiently using the STANDARD swimming POOL cartridges, and the non-standardized manual cleaning methods for cartridges may lead to pathogen and/or chemical exposure risks to PATRONS and employees at AQUATIC VENUES while the fouling of cartridges may lead to AQUATIC VENUES exceeding their maximum recommended TURNOVER times. Poor use of personal protective equipment and non-STANDARD cleaning of SPA cartridge filters led to non-tuberculosis mycobacterial infections in SPA workers²⁰⁸. Due to these health and SAFETY concerns, cartridge filter use is not recommended in AQUATIC VENUES.

Cleaning procedures for cartridges are not well-established and education in proper cleaning procedures is likely necessary to avoid contaminated cartridges being reinstalled into filters potentially providing a protected region for proliferation of biofilm bacteria the could lead to an outbreak. Cartridge filter elements are typically cleaned manually usually by hosing them down with a water hose and replacing them. Exposure concerns exist since concentrated streams containing *Legionella*, Mycobacteria, *Cryptosporidium*, and other pathogens can potentially be sprayed or splashed on the operator/lifeguard as well as the surrounding environment perhaps even including the inside of the filter or the surfaces surrounding the AQUATIC VENUES.

Oocysts. Journal AWWA. 2001;93(12):54-63.

²⁰⁸ Moraga-McHaley SA et al. Hypersensitivity pneumonitis with Mycobacterium avium complex among spa workers. J Occup Environ Health. 2013;19(1):55-61.

An extensive survey of manufactures' cleaning recommendations was conducted after there was a *Legionella* outbreak in a facility with cartridge filters. *Legionella*, *Pseudomonas*, and biofilms were found in the filters. The cleaning procedure employed was to take them outside, rinse them with a water hose, and replace them. Operators reported that they would occasionally degrease or bleach them. Further investigation revealed that this cleaning procedure was common at other facilities.

Filter manufacturers were surveyed for cleaning procedures and most often did not have a cleaning process and simply deferred to the cartridge manufacturer since many filter manufacturers do not make the cartridges. The cartridge manufacturers also did not have a cleaning procedure or a very minimal one that did not account for biofilms or heavy organic loads commonly encountered in SPAS. CHLORINE is generally ineffective at inactivating bacteria in a biofilm or removing particulate or organic filter foulants. One effective way to control the biofilms is to completely dry them out.

Based on the known poor performance in removing pathogens increasing the likelihood of waterborne disease outbreaks and the potential for dangerous microbial (and perhaps chemical) exposures to the operators during routine maintenance, cartridge filters are not currently recommended. This is not to say that all of the current issues and/or concerns with cartridge filters could not be resolved.

4.7.2.4.2 Filtration Rates

R&F

Cartridge filter elements should have a listed maximum flow rate of 0.375 gallons per minute per square foot (0.26 L/s/m²), but the design filtration rate for surface-type cartridge filter should not exceed 0.30 gallons per minute per square foot (0.20 L/s/m²). Cartridges don't recover 100% capacity when cleaned after fouling. Systems designed to the maximum limit cannot sustain performance (or minimum POOL TURNOVER requirements) over time. For example, if a filter only recovers to 80% of the original flux after cleaning, then a filter flow rate of 0.375 gallons per minute per square foot (0.26 L/s/m²) would become 0.30 gallons per minute per square foot (0.20 L/s/m²). Cartridge replacement would be necessary following fouling levels greater than 20% of the maximum rated capacity.

4.7.2.4.3 Elements

R&F

The pore size and surface area of replacement cartridges shall match the manufacturer's recommendations.

4.7.2.4.4 Spare Cartridge

R&F

An extra set of elements, with at least 100 percent filter area, and appropriate cleaning facilities and equipment should be provided to allow filter cartridges to be thoroughly cleaned. Two sets of filter cartridges should be supplied to allow for immediate replacement and cleaning procedures that involve complete drying of the filter elements.

4.7.3 Disinfection and pH Control

Disinfection and Indoor Air Quality

DWQ

To provide for a healthy and safe swimming environment in INDOOR AQUATIC FACILITIES, it is important to consider a number of issues that could impact health. Proper ventilation and humidity control are important in removing excess heat, moisture, noxious odors, and harmful DISINFECTION BY-PRODUCTS.²⁰⁹

Proper Chemical Use

DWQ

In addition, proper usage of chemicals can also improve the quality of the indoor air environment.^{210,211,212}

High Chloramines

DWQ

High levels of chloramines and other volatile compounds in the air can increase the possibility of health effects such as upper respiratory illnesses and irritation of the mucous membranes including eyes and lungs.^{213,214} Furthermore, these CONTAMINANTS can also cause metal structures and equipment to deteriorate.

Shock Oxidizer

DWQ

While proper ventilation is critical for INDOOR AQUATIC FACILITIES, water chemistry also can dramatically affect air quality. Levels of chloramines and other volatile compounds can be minimized by reducing CONTAMINANTS that lead to their formation (e.g., urea, creatinine, amino acids, and personal care products), as well as by supplemental water treatment. Effective filtration, water replacement, and improved BATHER hygiene can reduce CONTAMINANTS and chloramine formation. Research has shown that the use of non-CHLORINE shock oxidizers is selective in OXIDATION and may not prevent nor reduce inorganic chloramines though they may reduce some organic chloramines.²¹⁵ The EPA final guidelines state that manufacturers of “shock oxidizers” may advertise that their “shock oxidizer” products “remove,” “reduce,” or “eliminate” organic CONTAMINANTS.²¹⁶ Shock dosing with CHLORINE can destroy inorganic chloramines that are formed. SECONDARY DISINFECTION SYSTEMS such as ozone and ultraviolet light may effectively destroy inorganic as well as some organic chloramines.

Swimmer Education

DWQ

²⁰⁹ Chen L, et al. Health hazard evaluation report: investigation of employee symptoms at an indoor waterpark. Cincinnati, OH: US Department of Health and Human Services, CDC, National Institute for Occupational Safety and Health: 2008. Report no. HETA2007-0163-3062. Available at <http://www.cdc.gov/niosh/hhe/reports/pdfs/2007-0163-3062.pdf>.

²¹⁰ Bowen AB et al. Outbreaks of short-incubation ocular and respiratory illness following exposure to indoor swimming POOLS. *Environ Health Perspect*. 2007 Feb;115(2):267-71.

²¹¹ Kaydos-Daniels SC et al. Health effects associated with indoor swimming POOLS: a suspected toxic chloramine exposure. *Public Health*. 2008 Feb;122(2):195-200.

²¹² Centers for Disease Control and Prevention (CDC). Ocular and respiratory illness associated with an indoor swimming pool--Nebraska, 2006. *MMWR Morb Mortal Wkly Rep*. 2007 Sep 14;56(36):929-32.

²¹³ Hery M et al. Exposure to metallic catalyst dust: manufacturing and handling of catalysts in the chemical industry. *Ann Occup Hyg*. 1994 Apr;38(2):119-35.

²¹⁴ Massin N et al. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming POOLS. *Occup Environ Med*. 1998 Apr;55(4):258-63.

²¹⁵ Anipsitakis GP et al. Chemical and microbial decontamination of pool water using activated potassium peroxymonosulfate. *Water Res*. 2008 Jun;42(12):2899-2910.

²¹⁶ EPA Final Guidelines regarding “Shock Oxidizer” Products, <http://apsp.org/APSPWeeklye-ad/Aug20-08/Shock%20Oxidizer.html>

In addition, swimmers should be educated that their behavior (e.g., failing to shower, urinating in the POOL) can negatively impact air quality by introducing nitrogen-containing CONTAMINANTS that form volatile compounds.²¹⁷

Reduce and Minimize Impact

DWQ

These steps can help reduce the chemical role in creating poor indoor air quality, and help maintain an environment that minimizes health effects on BATHERS as well as decrease deterioration of AQUATIC FACILITIES and equipment.

4.7.3.1 Chemical Addition Methods

R&F

4.7.3.2 Feed Equipment

R&F

4.7.3.2.1 General

R&F

4.7.3.2.1.3 Controls and No or Low Flow Deactivation

RM

If recirculation pumps stop but chemical feed pumps continue to pump chemicals into the return lines it can result in a high concentration of acid and CHLORINE being mixed so that eventually when concentrated solutions of CHLORINE and acid are mixed, CHLORINE gas will be formed. The CHLORINE gas could be released into the AQUATIC VENUE when the pump is turned on again or in the pump room if there is an opening in the line. To prevent the hazardous release of CHLORINE gas, the chemical feed system shall be designed so that the CHLORINE and pH feed pumps will be deactivated when there is no or low flow in the RECIRCULATION SYSTEM.

4.7.3.2.2 Sizing of Disinfection Equipment

R&F

High use facilities, such as water parks and health clubs, require a greater capacity of feed equipment and production. These facilities generally have higher recirculation rates and experience accelerated consumption and should be sized differently to provide the minimum dosing

4.7.3.2.3 Introduction of Chemicals

R&F

4.7.3.2.4 Compressed Chlorine Gas

R&F

4.7.3.2.5 Types of Feeders

R&F

4.7.3.2.5.6 UV Systems

R&F

All UV units shall be installed into the system by means of a bypass pipe to allow maintenance on the UV unit while the POOL is in operation.

4.7.3.2.6 Salt Electrolytic Chlorine Generators, Brine Electrolytic Chlorine or Bromine Generators

R&F

²¹⁷ Chen L, et al. Health hazard evaluation report: investigation of employee symptoms at an indoor waterpark. Cincinnati, OH: US Department of Health and Human Services, CDC, National Institute for Occupational Safety and Health: 2008. Report no. HETA2007-0163-3062. Available at <http://www.cdc.gov/niosh/hhe/reports/pdfs/2007-0163-3062.pdf>.

4.7.3.2.7 Feeders for pH Adjustment R&F

4.7.3.2.7.5 Solution Reservoirs R&F

It is recommended that the solution's reservoir supply be sized to hold a minimum of one week's supply.

4.7.3.2.8 Automated Controllers R&F

4.7.3.2.8.1 Automated Controllers M&T

Constant and regular MONITORING of key water quality parameters such as the disinfectant level and pH are critical to prevent recreational water illness and outbreaks. AUTOMATED CONTROLLERS are more reliable as a MONITORING device than personnel and hand feeding chemical. Automated chemical controllers are therefore required for use on every AQUATIC VENUE with a time of 1 year built in for facilities to become compliant after adoption of this requirement. The use of AUTOMATED CONTROLLERS does not negate the requirements for regular water testing. Automated units require verification of proper function and the probes do fail or slip out of calibration. This can only be detected by MONITORING the water quality.

4.7.3.3 Secondary Disinfection Systems DWQ

4.7.3.3.1 General Requirements DWQ

4.7.3.3.1.2 Required Facilities DWQ

Due to the risk of outbreaks of recreational water illnesses (RWIs) associated with the disinfectant tolerant parasite *Cryptosporidium*, it is strongly recommended that all AQUATIC FACILITIES include SECONDARY DISINFECTION SYSTEMS to minimize the risk to the public associated with these outbreaks.

Increased Risk Aquatic Venues DWQ

However, there are some AQUATIC VENUES where the risk of acquiring a RWI is elevated (INCREASED RISK AQUATIC VENUES) due to either the use of the AQUATIC VENUE, or the users. THERAPY POOLS, for example, are often utilized by individuals with compromised immune systems and/or open wounds. The risk of acquiring an RWI is substantially increased under such circumstances. WADING POOLS are utilized by small children, who may be in diapers. Incontinent infants and small children are likely to increase the contamination burden (e.g.: urine and feces) in the water, thereby creating an INCREASED RISK of disease to other users. In addition, cryptosporidiosis is more prevalent in younger children.²¹⁸ Interactive water play venues such as spray pads, fountains, and similar features are most often used by smaller children who are likely to increase the risk of water contamination occurring. They also may be more likely to suffer from more severe illness when they become infected.

Intent DWQ

²¹⁸ Yoder JS et al; Centers for Disease Control and Prevention (CDC). Cryptosporidiosis surveillance - United States, 2006-2008. MMWR Surveill Summ. 2010 Jun 11;59(6):1-14.

The intent of requiring a SECONDARY DISINFECTION SYSTEM (SDS) is to limit the length of time of exposure to agents that cause diarrheal illness, in particular *Cryptosporidium*, after a fecal release in INCREASED RISK AQUATIC VENUES.

Facilities

DWQ

These facilities include THERAPY POOLS, and WADING POOLS, water ACTIVITY POOLS, INTERACTIVE WATER PLAY AQUATIC VENUES (E.G., SPRAY PADS, and other AQUATIC VENUES with no standing water designed primarily for young children including DIAPER-AGED CHILDREN (defined in the Code as children < 5 years old). In these facilities the potential of diarrheal illness is elevated due to the population mix of the PATRONS and the design of the facility. The pathogens of concern in such facilities are *Cryptosporidium*, *Giardia*, *Shigella*, *E. coli* O157:H7, and norovirus. *Shigella* and *E. coli* O157:H7 are very sensitive to traditional CHLORINE DISINFECTION. However, the seriousness of illness caused by highly (*Cryptosporidium*) and moderately (*Giardia*, norovirus) CHLORINE tolerant pathogens is the reason a SECONDARY DISINFECTION SYSTEM is **required** for all new or SUBSTANTIALLY ALTERED construction of these types of AQUATIC FACILITIES after the adoption of this code. When older facilities are SUBSTANTIALLY ALTERED, they must retrofit to meet this treatment requirement.

4.7.3.3.2 3-log Inactivation and Oocyst Reduction

DWQ

4.7.3.3.2.1 3-log Inactivation

DWQ

Examples of SECONDARY DISINFECTION SYSTEMS include but are not necessarily limited to: UV DISINFECTION and ozone DISINFECTION.

4.7.3.3.2.2 Installation

DWQ

SECONDARY DISINFECTION SYSTEMS are located in the treatment loop (post filtration) and treat a portion (up to 100%) of the recirculation flow prior to return of the water to the AQUATIC VENUE OR AQUATIC FEATURE.

4.7.3.3.2.4 Minimum Flow Rate Calculation

DWQ

The SECONDARY DISINFECTION SYSTEM is to be designed to reduce an assumed total number of infective *Cryptosporidium* OOCYSTS in the total volume of the AQUATIC VENUE from an assumed 100 million (10^8) OOCYSTS to a maximum concentration of 1 infective OOCYST/100 ml by means of consecutive dilution.

4.7.3.3.2.5 Equation

DWQ

In considering the potential for outbreaks, it was decided that a treatment system should be designed to limit the outbreak to a reasonable period of time, preferably to a single day of operation. By this, it is meant that all pathogens of concern that may still be present at infective concentrations at the close of operations are reduced to below a level of infectivity by the opening time of the following day. This approach has been recommended because numerous multi-day outbreaks have been well documented.

^{219,220,221} In order to design a treatment system that can reduce the duration of exposure to a single day the MAHC Committee made the following assumptions:

- The target of concern is *Cryptosporidium*. Based on known CT VALUES, all other pathogens will be inactivated within an hour if the facility is maintaining at least 1ppm of free CHLORINE.
- At a concentration of 1 ppm free CHLORINE any *Cryptosporidium* OOCYSTS left circulating in the water may be infective for up to 15,300 minutes (>10 days) after introduction.
- A single contamination event (e.g. diarrheal incident) of ~100ml could introduce 10^8 *Cryptosporidium* OOCYSTS into the water.^{222,223}
- Reducing the amount of *Cryptosporidium* below the level at which there is one infectious OOCYST per average volume swallowed by swimmers (16-128ml) would be a reasonable target for overnight remediation of the water to reduce the risk of transmission beyond the day of initial contamination.^{224,225} The concentration chosen was one OOCYST/100ml.
- The only effective means currently to reduce the concentration of OOCYST in an AQUATIC VENUE is by dilution. Accomplishing this through the introduction of sufficient makeup water is not practical. Instead, the solution is to remove a portion of the water, treat it to reduce the concentration of infectious OOCYSTS, and then return that water to the AQUATIC VENUE.
- SECONDARY DISINFECTION SYSTEMS can practically achieve a 3 log (99.9%) reduction in the number of infective OOCYSTS per pass through the SECONDARY DISINFECTION SYSTEM.
- Due to imperfect mixing and other real work constraints, a SAFETY factor of 1.33 has been applied to the maximum dilution time, as defined as the time it will take for 10^8 OOCYSTS introduced into an AQUATIC VENUE (i.e. a diarrheal event) to be reduced to a maximum concentration of 1 OOCYST per 100 ml.
- A reasonable expected overnight closure time for an AQUATIC VENUE is 12 hours (e.g. 8 p.m. to 8 a.m.). Therefore 9 hours has been established as the maximum dilution time ($12 / 1.33$ or 12×0.75) to be used when sizing a SECONDARY DISINFECTION SYSTEM. If the actual expected closure time of a venue is less than 12 hours, then 75% of that value shall be used for the dilution time.

²¹⁹ Causer L et al. An outbreak of *Cryptosporidium hominis* infection at an Illinois recreational waterpark. Epidemiol Infect. 2006 February; 134(1): 147–156.

²²⁰ Wheeler C et al. Outbreak of cryptosporidiosis at a California waterpark: employee and patron roles and the long road towards prevention. Epidemiol Infect. 2007 Feb;135(2):302-10.

²²¹ Centers for Disease Control and Prevention (CDC). Communitywide cryptosporidiosis outbreak--Utah, 2007. MMWR Morb Mortal Wkly Rep. 2008 Sep 12;57(36):989-93.

²²² Chappell CL et al. *Cryptosporidium parvum*: intensity of infection and oocyst excretion patterns in healthy volunteers. J Infect Dis. 1996 Jan;173(1):232-6.

²²³ Goodgame RW et al. Intensity of infection in AIDS-associated cryptosporidiosis. J Infect Dis. 1993 Mar;167(3):704-9.

²²⁴ Dufour AP et al. Water ingestion during swimming activities in a pool: a pilot study. J Water Health. 2006 Dec;4(4):425-30.

²²⁵ Allen LM et al. Absorption and excretion of cyanuric acid in long-distance swimmers. Drug Metab Rev. 1982;13(3):499-516.

Any treatment system that demonstrates this reduction in *Cryptosporidium* OOCYSTS specified herein is suitable for use. It is not the intent of the MAHC to limit technology only to UV and ozone as discussed in the CODE, but rather to specify the outcome of the treatment.

Purpose

DWQ

The purpose of secondary DISINFECTION is to reduce the viable *Cryptosporidium* OOCYSTS to a number below that which is considered an infective concentration, should the parasite be introduced into an AQUATIC VENUE. While 100% UV treatment of recirculated water is an option, it is important to note that this will not ensure the SAFETY of the PATRONS immediately following a fecal event, but it will reduce the time required for the system to get below an infective dose. While this is beneficial, mandating UV on 100% of the recirculated water flow may lead owners and designers to minimize the total recirculated flow so as to not incur the additional capital and operating cost of the required additional UV, ozone, or other SECONDARY DISINFECTION SYSTEMS. *Cryptosporidium* control is not the only consideration when designing an INCREASED RISK AQUATIC VENUE, and it is important that this requirement does not negatively influence other design considerations—such as amount of filtration needed for particulate removal and control of turbidity.

Consideration was therefore given to what should be the maximum time a system takes to reduce the viable OOCYST concentration to below an effective dose. Because a fecal event can release 100 million OOCYSTS and an infective dose is as little as 1 OOCYST per 100 mL, it is impossible with available technology today to ensure the SAFETY of BATHERS in the AQUATIC VENUE both at the time the fecal event occurs and in the immediate aftermath. A reasonable and logical maximum time for reducing the OOCYST concentration to below 1 OOCYST/100mL was determined to be the lesser of 9 hours or 75% of the time an AQUATIC VENUE is closed in a 24 hour period. The goal of this is to ensure an AQUATIC VENUE is free of viable *Cryptosporidium* OOCYSTS, or at least have the number below an infective concentration every day the AQUATIC VENUE opens to the public.

Example of Equation

DWQ

The actual calculation used to determine the amount of needed secondary DISINFECTION is based upon the understanding that the treatment of recirculated AQUATIC VENUES involves serial dilution, whether we are talking about particulate removal or rendering *Cryptosporidium* OOCYST ineffective. Assuming an initial concentration of 10^8 OOCYSTS, recognizing the limit of an infective dose is 1 OOCYST/100 mL, and allowing for a 99.9% reduction in infective OOCYST by the SECONDARY DISINFECTION SYSTEM, it can be derived that needed flow through the SECONDARY DISINFECTION SYSTEM is as given in the code.

An example of how to calculate for the needed flow is as follows:

- For a 100,000 gallon venue which is closed 12 continuous hours out of every 24 hours, 75% of which is 9 hours...

- $100,000 \times ((14.8 - \ln (100,000)) / (60 \times 9))$
= 609 gpm

Therefore, the 100,000 gallon venue would require a SECONDARY DISINFECTION SYSTEM which has a flow rate of at least 609 gpm. If this AQUATIC VENUE is designed with a 2 hour filtration TURNOVER rate, the flow through the filters would be 833 gpm. An owner or designer can choose to size the SECONDARY FILTRATION SYSTEM to be 609 gpm, 833 gpm, or anything in between. If the owner or designer chooses to size the SECONDARY DISINFECTION SYSTEM equal to the filtration flow rate (833 gpm) the time it would take to reduce 10^8 OOCYST to 1 OOCYST/100 mL would be 6.6 instead of 9 hours.

4.7.3.3.2.7

Flow Rate Measurements

DWQ

Consideration was given for simplifying the sizing of the SECONDARY DISINFECTION SYSTEM and having the flow rate through the SECONDARY DISINFECTION SYSTEM equal to the overall treatment system flow rate. While this was recommended by the MAHC Committee, ultimately this approach was rejected. A basic premise of the MAHC is to establish performance-based STANDARDS supported by data and science whenever possible. Sizing the SECONDARY DISINFECTION SYSTEM equal to the overall treatment system flow rate, while simplifying the design and operation of the facility, does not meet any defined criteria for reducing or eliminating risk to the PATRONS using the AQUATIC FACILITY. It was felt that establishing specific criteria for sizing the SECONDARY DISINFECTION SYSTEM independent of the criteria for sizing other treatment system processes (e.g. filtration flow rate) was the approach most likely to protect the public's health.

Maximum Concentrations

DWQ

In developing this approach, the MAHC Committee considered establishing maximum permissible concentrations of OOCYSTS, which would be monitored and verified, but rejected that approach as impractical since it would require actual lab testing.

Establishing a concentration based STANDARD for the water cannot be readily be implemented because:

- There is no practical method to rapidly determine the number of OOCYSTS in the water and thus no method to enforce the STANDARD
- There are multiple and interrelated biological variables in exposure estimations. These including the number of OOCYSTS released per fecal incident, the number of incidents per day, strain differences in pathogenicity, the amount of water swallowed, and differences in individual susceptibility.
- The circulatory patterns in facilities are complex and unique to each AQUATIC FACILITY.

Requiring that the SECONDARY DISINFECTION SYSTEM deliver a treatment that ensured the OOCYST concentration was reduced to a specified level would require multiple biological assumptions and computer modeling that exceed those currently required for any other water parameter.

4.7.3.3.3 Ultraviolet Light Systems**DWQ**

UV DISINFECTION is a SECONDARY DISINFECTION SYSTEM and must meet the minimum requirements of all SECONDARY DISINFECTION SYSTEMS as defined in MAHC Section 4.7.3.3. The minimum requirements must be read in conjunction with the clarifications and additional information as detailed below.

4.7.3.3.3.1 Third Party Validation**DWQ**

Validation to a recognized national STANDARD is carried out by a recognized and capable third party. Such validation needs to take into consideration lamp life, UV MONITORING, and optical water quality. Typical POOL water qualities vary, but a design UV TRANSMISSIVITY assumption of better than 94% T10 should not be used. Where possible, transmissivity tests should be obtained for existing facilities.

4.7.3.3.3.1.1**Validation Standard****DWQ**

Validation is a process by which any UV unit is tested against a surrogate microorganism in order to determine its performance. Validation is required because there is no on-line test of a UV unit's ability to disinfect and, due to the relatively short contact time, it is impossible to size units accurately based on just calculations.

It is important to note that evidence of testing is not the same as validation.

Validation must adhere to the following criteria:

- follow one of the approved validation systems, preferably the USEPA DGM 2006,
- have been carried out by a genuine third party, and
- include all the required validation factors and RED bias.

The validated performance is based on the flow and transmissivity of the water to be treated. Therefore it is essential that the system is used within its validated performance range. A system operated outside its validated range is NOT acceptable.

Validation Factor**DWQ**

The validation factor is used to account for statistical variations in the recorded data during third party testing. The validation factor is required to ensure that the equipment's actual performance will always be equal to or better than its validated performance. This figure can be between 15% and 35% depending on the quality of the testing and must be included in any validated performance curve.

Transmissivity (Transmission)**DWQ**

The transmissivity (often called transmission) of the water to be treated is an important design factor in sizing a UV system. The transmissivity is normally quoted as a % value in either a 1cm, 4cm, or 5cm cell. It is measured in a UV Spectrophotometer.

In many water treatment applications, this value will vary considerably but AQUATIC VENUES are for the most part consistent, due to the bleaching effect of the CHLORINE used as a residual disinfectant.

Typically AQUATIC VENUES will have a transmission of between 94% and 95% in a 1 cm cell, with splash pads and other INTERACTIVE WATER PLAY VENUES between 92% and 94%.

The installation of a UV unit itself will increase the transmission by perhaps 2% due to the improvement in the POOL water quality so the values noted above are with a UV unit installed and operational.

Design transmissions over 94% are not recommended, and exceptionally heavily loaded AQUATIC FACILITIES may consider using a lower number as a design basis.

It is also important to understand that as transmission is reduced, the performance of the equipment is reduced and the RED bias increases, requiring the UV to deliver more performance. For this reason, the performance difference between any equipment's validated performance at 98% transmissivity and actual field performance at 94% transmissivity can be 40% lower. When presented with validated performance data at 98% transmission operators should therefore be aware that the equipment may only deliver half the performance when installed.

Validation Range DWQ

A validated system will have different performance levels at different water qualities and flows. The relationship between these is traditionally represented as a performance curve where the performance can be noted at any point on this curve. However the lowest transmission test point and the highest flow tested are normally considered the extents of the validated range. This means that any UV unit tested at 95% and above is NOT validated at transmissions lower than 95%. For the same reason a unit tested at a maximum flow of 500gpm is NOT validated for any flow over 500gpm.

Validation factors can reduce equipment validated performance by 30%, so it is essential that systems without validation factors built into performance curves are not considered validated.

The performance of a UV system in the field is measured by a combination of flow and intensity readings from the UV sensors. Performance in the field can be verified on inspection by regulators who will compare actual sensor readings with those indicated on the performance charts, so these charts must be retained at the AQUATIC FACILITY for each validated system.

UV equipment is utilized for its ability to disinfect CHLORINE-tolerant pathogens and for its ability to reduce combined CHLORINES in the POOL water. For the latter, typically a calculated dose of $60\text{mJ}/\text{cm}^2$ is utilized based on the total UV-C and UV-B spectrum. This is similar to the validated dose requirements of the SECONDARY DISINFECTION SYSTEMS.

Where UV is fitted as a SUPPLEMENTAL TREATMENT SYSTEM the CODE allows some operational and equipment concessions. Operators should note that the regulations as stated represent BEST PRACTICE; but where specific circumstances dictate, then the equipment specifications may be reduced.

For a SUPPLEMENTAL TREATMENT SYSTEM, the operator may consider reducing the dose applied to the process. This will reduce performance accordingly and operators should consider carefully such reduction in performance, and assure themselves that the equipment will still provide a beneficial level of performance.

4.7.3.3.3.10.1

RED Bias

DWQ

The USEPA identifies the required dose for various organisms to achieve 3- or 4-log reduction. This dose must be modified by the RED bias in order to ensure delivery of validated performance. Depending on the quality of the water, this RED bias can be between 35% and 70%.

4.7.3.3.4 Ozone Disinfection

DWQ

4.7.3.3.4.1 3-log Inactivation

DWQ

Ozone is a SECONDARY DISINFECTION SYSTEM and must meet the minimum requirements of all SECONDARY DISINFECTION SYSTEMS as defined in MAHC Section 4.7.3.3.

Ozone is an antimicrobial oxidizer. Its use as a SECONDARY DISINFECTION SYSTEM in commercial swimming POOLS in the U.S. dates back to the 1930's. Ozone is proven to kill *Cryptosporidium*²²⁶, *Giardia*²²⁷, *E. coli*²²⁸, and *Pseudomonas aeruginosa*²²⁹, along with any other microorganism potentially found in AQUATIC VENUES, and is a strong oxidizer, exposure to ozone gas can result in irritation to the eyes and respiratory tract if not generated and handled correctly. Therefore the Occupational Safety and Health Administration (OSHA) has identified a time weighted average (TWA) of 0.1 PPM (0.2 mg/m³) as the permissible exposure limit for ozone.

4.7.3.3.4.2 Third Party Validation

DWQ

Validation is a process by which any ozone unit is tested against a surrogate microorganism in order to determine its performance. Validation is required because there is no on-line test of an ozone unit's ability to disinfect and, due to the relatively short contact time, it is impossible to size units accurately based on just calculations.

It is important to note that evidence of testing is not the same as validation.

²²⁶ Korich DG et al. Effects of ozone, chlorine dioxide, chlorine, and monochloramine on *Cryptosporidium parvum* oocyst viability. Appl Environ Microbiol. 1990 May;56(5):1423-8.

²²⁷ Wickramanayake GB et al. Inactivation of *Giardia lamblia* cysts with ozone. Appl Environ Microbiol. 1984 Sep;48(3):671-2.

²²⁸ Cho M et al. Mechanisms of *Escherichia coli* inactivation by several disinfectants. Water Res. 2010 Jun;44(11):3410-8.

²²⁹ Zuma FN et al. Kinetics of inactivation of *Pseudomonas aeruginosa* in aqueous solutions by ozone aeration. J Environ Sci Health A Tox Hazard Subst Environ Eng. 2009 Aug;44(10):929-935.

NSF/ANSI Standard 50 is including the ozone/*Cryptosporidium* validation STANDARD into Standard 50; it is not an Annex but a portion of the ozone section in the whole STANDARD and will be published in the final 2013 STANDARD.

4.7.3.3.4.3 Suitable for Use

DWQ

All materials must be ozone resistant.

The strong oxidizing power of ozone shall be considered when choosing materials for pipes, valves, gaskets, pump diaphragms, and sealant. Materials for water piping, tanks, and other conveyance shall be nearly inert.

For generators that produce ozone under pressure and utilize a negative pressure (Venturi) ozone delivery system, or introduce ozone under pressure (such as a pressurized diffuser into an atmospheric holding tank), any leak or break in the system will immediately cause the release of ozone gas.

Suitable materials and their uses are:

1. Ozone/Air or Ozone/Oxygen:

- Concentrations above 2500 PPM (MG/L) (0.4 % wt)
- PTFE, FEP (Teflon®) – tubing, o-rings, or ozone cell materials
- PVDF (Polyvinylidene Fluoride), Kynar® (Pennwalt patent) – tubing, injection, check valves
- Stainless Steel, grade 316L – tubing or ozone cell materials
- Glass and most ceramics – ozone cell materials
- Aflas® – seals, O-rings, gaskets
- Concentrations below 2500 (in addition to those above)
- Viton® – tubing, seals, O-rings
- Kel-F® – seals & O-rings

NOTE: *Stainless steel tubing shall only be used when the feed-gas is dried to a dew point below –76 °F (-60° C), and where no chance of water ingress exists. Corrosive acids formed in moist air will corrode the pipes from the inside.*

2. Dissolved Ozone in Water (in addition to all those listed above):

- PVC or CPVC (schedule 40 or 80)
- EPDM (Ethylene - propylene terpolymer)
- PVDF (Polyvinylidene Fluoride), Kynar® (Pennwalt patent)

3. Gaskets and O-rings

- Aflas®, Kalrez®, and Teflon® are acceptable gasket materials for both gas and aqueous seals.
- Viton®, EPDM, and “Red Silicon” do not provide sufficient resistance to deterioration at ozone concentrations above 1.5% (gaseous) but work well in

aqueous ozone solutions. If used for gaseous application, these shall only be used in static seals and replaced regularly.

4. Joint Sealing

Properly applied Teflon tape may be used successfully for sealing joints; however, threaded fittings shall be avoided where possible. Hypalon® and silicone sealers which do not contain rubber filler are also successful.

4.7.3.3.4.7.2

Gas Monitor/Controller

DWQ

For generators that produce ozone under pressure and utilize a negative pressure (Venturi) ozone delivery system, or introduce ozone under pressure (such as a pressurized diffuser into an atmospheric holding tank), any leak or break in the system will immediately cause the release of ozone gas.

4.7.3.4

Supplemental Treatment Systems

DWQ

4.7.3.4.1

General Requirements

DWQ

4.7.3.4.1.1

Optional

DWQ

AQUATIC VENUES that do not require SECONDARY DISINFECTION SYSTEMS have the option to utilize SUPPLEMENTAL TREATMENT SYSTEMS. These systems may not afford DISINFECTION protection against *Cryptosporidium*, and may not remove chloramines as effectively as SECONDARY DISINFECTION SYSTEMS. However, if sized within supplementary treatment system requirements in MAHC Sections 4.7.3.4, a SUPPLEMENTAL TREATMENT SYSTEM may be of benefit in maintaining air quality at indoor facilities, reducing the *Cryptosporidium* burden over an extended period of time, and reducing the amount of disinfectant needed to maintain required disinfectant levels.

Although SUPPLEMENTARY TREATMENT SYSTEMS are optional, it should be noted that this CODE, as written, represents BEST PRACTICE.

4.7.3.4.2

Ultraviolet Light

DWQ

Refer to information presented in MAHC Section 4.7.3.3.3 of this Annex.

4.7.3.4.3

Ozone

DWQ

Refer to information presented in MAHC Section 4.7.3.3.4 of this Annex.

4.7.3.4.4

Copper/Silver Ion System

DWQ

The scientific data available on efficacy of these systems is predominantly for bacterial inactivation and usually includes FREE AVAILABLE CHLORINE.^{230,231}

²³⁰ Yahya MT et al. Disinfection of bacteria in water systems by using electrolytically generated copper:silver and reduced levels of free chlorine. Can J Microbiol. 1990 Feb;36(2):109-16.

²³¹ Beer CW et al. Swimming Pool Disinfection: Efficacy of copper/silver ions with reduced chlorine levels. J Environmental Health, 61(9): 9-12.

There is limited scientific literature that documents the efficacy of these systems on viruses and parasites.

Given the importance and frequency of recreational water illnesses associated with these other microorganisms (viruses and parasites), it is essential that DISINFECTION chemicals / systems are also effective against such microorganisms as well.

4.7.3.4.5 Ultraviolet Light / Hydrogen Peroxide Systems DWQ

UV-peroxide systems have not been registered by the US EPA as primary disinfectant systems for recreational water. Although UV is a disinfectant, it does not impart a persistent residual disinfecting property to water. To overcome this, UV-peroxide systems claim, or in some cases imply, that the inclusion of hydrogen peroxide in the system supplies a disinfectant in the bulk water in the AQUATIC VENUE. Hydrogen peroxide is used as a hard surface disinfectant and has been granted registration for this purpose by the US EPA. When used as a hard surface disinfectant, hydrogen peroxide is normally used at around 3%. When used in recreational water, hydrogen peroxide is used at 27 to 100 PPM (MG/L), which is 1111 and 300 times, respectively, more dilute than that used on hard surfaces. At these low concentrations hydrogen peroxide is not an effective disinfectant. Thus, UV-peroxide systems do not provide a persistent disinfectant in the bulk of the water in the AQUATIC FACILITY. Further, hydrogen peroxide is not registered by the US EPA for use as a disinfectant in recreational water. Since it is not EPA-REGISTERED, the use of hydrogen peroxide as a disinfectant, or any market claims that implies hydrogen peroxide provides any biological control, is a violation of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

UV-peroxide system should not be used as a SUPPLEMENTAL TREATMENT SYSTEM ON CHLORINE treated AQUATIC VENUES. The addition of hydrogen peroxide to a CHLORINE-treated POOL will inactivate the hypochlorous acid. If sufficient hydrogen peroxide is added, the hypochlorous acid will be completely eliminated and no disinfectant for inactivation of pathogenic organisms will remain.

4.7.3.5 Testing for Water Quality and Circulation M&T

WQTDs should be stored as specified by the manufacturer's instructions. Failure to properly store WQTSs will result in incorrect readings. NSF/ANSI Standard 50 for WQTDs in 2011 currently contains specified precision and accuracy requirements for measuring pH, free & total CHLORINE, and free & total bromine. There are three levels of accuracy and precision deemed level 1, 2 & 3, with the highest accuracy and precision in level 1 devices. The test water specifications include alkalinity, calcium hardness, and total dissolved solids.

It is important for a QUALIFIED OPERATOR to use equipment that is easy to read and as objective as possible. The current, common means of testing POOLS using colorimetric test kits is highly subjective because the color and intensity must be compared. Titration testing for free and combined CHLORINE is an objective test, which is accurate to 0.2 mg/L with an easily recognizable start and end point. Titration testing is recommended over colorimetric testing. Due to the use of inconsistent concentration gradations (i.e.,

the difference in concentration between adjacent color blocks) and the subsequent rapid darkening of the color blocks (e.g., above 1.5 mg/L), the accuracy of colorimetric test methods is likely to be lower than for titration test methods. Visual colorimetric methods are accurate only to +/- half the difference between the adjacent color blocks, and thus the confidence limits for these methods are wider at higher concentrations (e.g., above 1.5 mg/L). Where portable colorimeter test kits are affordable, these are the most accurate kits available for use at POOLSide.

Most water tests involve color development. Interferences in the water can cause them to produce a different color, or produce the wrong color intensity, or be unable to produce the expected color. Color matching tests for CHLORINE/bromine provide accuracy equal to approximately half the difference between known values of the color STANDARDS. As the CHLORINE/bromine concentration rises, the greater the difference will be between the known color STANDARDS. Thus, the readings become subjective as the difference increases. The following chart summarizes some common interferences and how they impact the test color in disinfectant tests.

Table 4.7.3.7: Water Tests and Interference

M&T

Test	Interference			
	High Chlorine	Metals : Cu, Fe, Mn	High Calcium	Monopersulfate
Chlorine	At approximately 10 ppm, may cause partial or total bleaching of the DPD reagents, resulting in lower pink color intensity, or no pink color at all.	None	May cause the sample to turn cloudy white when adding DPD #1.	Will cause a false positive (more intense pink color) for combined chlorine at any level and for free chlorine at high levels (over 25 ppm).
pH	May create a different indicator, chlorphenol red, that is purple at pH 6.6 and higher	None	None	None
Total Alkalinity	May cause the beginning color to be light blue and the end-point to be yellow, rather than the expected starting green color and red (pink) endpoint.	None	None	None
Calcium Hardness	None	Expected blue color never fully develops, and the endpoint approaches blue, but fades to a light purple.	None	None

High chlorine effects on chlorine testing:

M&T

If the water sample indicates high CHLORINE levels, usually over 10 ppm, the DPD reagents may partially or totally bleach out, resulting in a false low or zero CHLORINE reading. The addition of double the quantity of DPD reagent during testing may minimize this interference or the analyst can use a smaller sample size or dilute the sample with distilled or deionized water (DI) water. Reference the WQTD's use instructions to guard against false readings and interferences.

High chlorine effects on pH testing:

M&T

If the CHLORINE reading is high, the consumer must wait until it is lowered to a normal level before retesting the pH, to assure an accurate reading. Some analysts neutralize the SANITIZER first by adding a drop of CHLORINE neutralizer (i.e., sodium thiosulfate). This is not recommended since the reaction between thiosulfate and CHLORINE can change the pH of the sample and give an inaccurate reading.

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High chlorine effects on total alkalinity testing:**M&T**

High CHLORINE will affect the Total Alkalinity reading. Some reagents will bleach out and the color change will be from blue to yellow instead of the expected green to red (pink). Refer to the WQTD's instruction manual to prevent false readings and interferences.

Metals:**M&T**

Be sure to identify the source of the metal in order to remove the problem for the POOL owner. Likely sources are copper from algaecides or corroded pipes, or iron and manganese from the fill water.

Effect of metals on calcium testing:**M&T**

For the calcium test, copper, iron, and manganese dissolved in the water may prevent the expected blue color (indicating the end of the test) from fully developing. As the end of the test approaches blue, it fades to a light purple instead, which results from the metals in the water. Repeat the test, but before proceeding with the test instructions, add 5 or 6 drops of titrant. Remember to add the 5 or 6 drops to your final drop count when finished to determine the calcium concentration.

High calcium effects on chlorine testing:**M&T**

When high calcium levels are in the water, the sample may turn cloudy with the addition of DPD #1 liquid reagent, which is alkaline. Addition of DPD #2 liquid reagent may not clear up the cloudiness. With high calcium water, adding DPD #2 prior to adding DPD #1 will acidify the sample, turning it slightly pink, and the cloudiness will not appear. Add DPD #1 to complete the test and obtain the proper pink color for the amount of CHLORINE in the water.

Potassium Monopersulfate Shock:**M&T**

Potassium monopersulfate produces a false high combined CHLORINE reading whenever it is present in the water. Monopersulfate will also produce a false positive free CHLORINE reading when the monopersulfate concentration is high (over 25 ppm). Monopersulfate interference can be removed by a variety of products found in the market place. Refer to the WQTD's instruction manual to prevent false readings and interferences.

4.7.3.6 Microbiological Testing Equipment**M&T**

Microbiological testing equipment and methods should be EPA-Approved, conforming to the latest edition of STANDARD Methods for the Examination of Water and Wastewater,²³² existing professional guidelines, or other recognized international guidelines or STANDARDS.

At this time, routine microbiological testing for POOLS, hot tubs, and other AQUATIC VENUES is not recommended in the MAHC. Routine MONITORING of chemical levels (e.g., pH, disinfectant concentration) and proper operation and maintenance of the AQUATIC VENUE have historically been considered to be sufficient to ensure that proper BARRIERS

²³² APHA et al. (2012) *Standard Methods for the Examination of Water and Wastewater*, 22nd ed. E.W. Rice, R.B. Baird, A.D. Eaton, and L.S. Clesceri (eds). New York: American Public Health Association.

are maintained to minimize potential infectious disease risks from CHLORINE sensitive pathogens. Currently, routine MONITORING for CHLORINE-resistant microorganisms (e.g., *Cryptosporidium* spp.) is not a feasible and cost-effective disease prevention approach. Chemical tests such as Free Residual CHLORINE, pH, Contact Time (CT) values and others provide a good indication of operational control of an AQUATIC VENUE. However, while these tests provide an indication of DISINFECTION potential, they may not provide complete assurance of the microbial quality of AQUATIC VENUE water.

While agencies such as the World Health Organization²³³, the South Australia Environmental and Public Health Service²³⁴, and the United Kingdom Health Protection Agency²³⁵ have established STANDARDS for routine MONITORING of public and semi-public AQUATIC VENUES for microbial parameters including enteric bacteria (fecal organisms or *E. coli*), *Pseudomonas aeruginosa* and *Legionella*, there is insufficient scientific data for the purposes of this MAHC to indicate that these routine MONITORING STANDARDS provide an increased level of public health protection beyond adherence to current BEST PRACTICES. The routine MONITORING recommendations in the MAHC can be reconsidered to potentially include routine MONITORING for microbial parameters if compelling scientific data indicate that such testing provides additional, measurable public health protections beyond use of BEST PRACTICES for DISINFECTION, AQUATIC VENUE operation and maintenance. It should be noted that this section of the Annex is a minimum guideline for microbiological MONITORING. AQUATIC VENUE operators wishing to achieve additional microbial water quality characterization are encouraged to use the references in this Annex regarding water quality MONITORING techniques and STANDARDS established by US states and in other countries. Microbial water quality STANDARDS established for POOLS and SPAS by US and international agencies include:

- **Alberta Public Health**, Alberta Regulation 293/2006 (2006) Swimming POOL, WADING POOL and Water Spray Park Regulation; Alberta, Canada
 - Excerpt, Page 10, Bacterial Limits: Heterotrophic Plate Count less than 100/mL; *Pseudomonas aeruginosa* 0/100 mL, coliforms 0/100 mL
- **Code de la Santé Publique, FRANCE**, (2007) Arrêté préfectoral en date du 15 juin 2007 fixant les upermens du contrôle sanitaire de la qualité des eaux des piscines (Prefectural order dated June 15, 2007 establishing STANDARDS for the control of swimming POOL water quality)
 - Excerpt: Determination of the parameters to be analyzed in the field or laboratory:

Standards for Bacteriological Analytical Parameters

- Viable aerobic bacteria at 37°C <100/ml
- Total coliforms <10/100ml

²³³ WHO. (2006) *Guidelines for safe recreational waters*. Volume 2. Swimming pools and similar recreational environments. Geneva, Switzerland:WHO. Retrieved from http://whqlibdoc.who.int/publications/2006/9241546808_eng.pdf

²³⁴ Broadbent C. (1996) *Guidance on water quality for heated spas*. Rundle Mall, South Australia: Public and Environmental Health Service.

²³⁵ Newbold J. (2006) *Management of spa pools: controlling the risk of infection*. London, United Kingdom: Health Protection Agency.

- Fecal coliforms (E. coli) 0/100ml
- Pathogenic staphylococci 0/100ml
- *Pseudomonas aeruginosa* (in SPAS) 0/100ml

New Jersey Department of Health and Senior Services (2009) New Jersey State Sanitary Code, Chapter IX, Public Recreational Bathing N.J.A.C 8:26

- Excerpt: pages 20 – 21; Heterotrophic plate count do not exceed 200 colonies per one milliliter sample; Coliforms to be less than one colony per 100 milliliter sample, *Pseudomonas aeruginosa* not to exceed one colony per 100 milliliter sample.

Although routine microbial testing is not recommended by the MAHC at this time, microbiological testing can be useful as supporting data for evaluating the need for (or effectiveness of) troubleshooting activities, remediation activities, and AQUATIC FACILITY upgrades. As indicated by WHO²³⁶ recommendations, microbiological testing of water samples from AQUATIC VENUES can be useful for the following reasons:

- Before an AQUATIC VENUE is used for the first time,
- Before it is put back into use after it has been shut down for repairs or cleaning,
- If there are difficulties with the treatment system, or
- As part of any investigation into possible adverse effects on BATHERS' health.

It is known that certain microorganisms, because of their ecology and/or structure, can be resistant to chemical disinfectants (e.g., CHLORINE, bromine). *Legionella pneumophila*, *Pseudomonas aeruginosa*, *Cryptosporidium parvum* OOCYSTS, *Entamoeba histolytica* cysts, and *Mycobacterium avium* complex are a few examples of pathogenic microbes that have been reported to show some resistance to chemical disinfectants. In addition, sessile microorganisms in biofilm are likely to receive additional protection from oxidizers (such as CHLORINE) when the exposure concentration of these oxidizers is reduced at the interface with the biofilm due to reaction with biofilm material.

Biofilm is a complex community of microorganisms which attach to the sides, piping, and filters of SPAS and POOLS²³⁷. Even at elevated concentrations, oxidizing and non-oxidizing chemicals have reduced effectiveness in controlling biofilm when their concentrations and contact times are not sufficient for penetrating the biofilm²³⁸. Biofilm formation in AQUATIC VENUES is also a concern because microorganisms in the biofilm or the biofilm itself can detach and multiply²³⁹. Following BEST PRACTICE guidelines for

²³⁶ WHO. (2006) Guidelines for safe recreational waters. Volume 2. Swimming pools and similar recreational environments. Geneva, Switzerland:WHO. Retrieved from http://whqlibdoc.who.int/publications/2006/9241546808_eng.pdf

²³⁷ Camper AK et al. (1985) Growth and persistence of pathogens on granular activated carbon filters. *Journal of Applied Environmental Microbiology*, 50:1378–82.

²³⁸ Pearson W. (2003) "Legionella 2003." *Association of Water Technologies Inc.*, Association of Water Technologies, 2003. Web. 19 Aug 2010. Retrieved from <http://www.awt.org/IndustryResources/Legionella03.pdf>

²³⁹ Declerck P. (2010) Biofilms: the environmental playground of *Legionella pneumophila*. *Environmental Microbiology*, 12(3), 557-566.

AQUATIC VENUE cleaning and continuous DISINFECTION is critical to avoid biofilm growth and expansion problems^{240,241}.

If biofilm-related problems arise, it can be useful to incorporate biofilm sampling to develop a comprehensive evaluation of the risk factors for water quality impairment and potential solutions to identified problems²⁴².

MAHC Annex Table 4.7.3.9 (below) identifies microorganisms for which chlorination may have, or is known to have, reduced efficacy^{243,244,245}. MAHC Annex Table 4.7.3.9 also identifies methods that may be used to detect these microbes in AQUATIC VENUE systems, but the methods identified are not necessarily rapid. Additional research is needed to evaluate the benefits of microbiological testing data for AQUATIC VENUES, especially for improving public health protection. This is particularly important for the protozoans, amoebas, and sessile bacterial pathogens that co-exist in biofilms. It should be noted that the use of fecal indicator organisms for AQUATIC VENUE water quality evaluation may not be sufficient for certain AQUATIC VENUE operation, maintenance, and public health investigations, especially in public health investigations related to inhalation, skin breaks, or ocular exposure routes. Since health risks in AQUATIC VENUES and similar environments may be fecal or non-fecal in origin, investigation of fecal indicators and non-fecally-transmitted microorganisms (e.g. *P. aeruginosa*, *S. aureus* and *Legionella* spp.) may be warranted.

Table 4.7.3.9: Known Pathogenic Organisms of Concern in Chlorinated Aquatic Venues M&T

²⁴⁰ Clements W. (Ed) (2000) *ASHRAE guideline: Minimizing the risk of legionellosis associated with building water systems*. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc.

²⁴¹ Donlan RM and Costerton JW. (2002) Biofilms: survival mechanisms of clinically relevant microorganisms. *Clinical Microbiology Review*, 15, 167-93.

²⁴² Paulson D. (Ed.) (2010) *Applied biomedical microbiology: A biofilms approach*. Chapter 8: Matias F, et. al., Disinfection and its influence on biofilm ecology . Chapter 9: Goerers D, Understanding the importance of biofilm growth in hot tubs. Boca Raton, FL: CRC Press.

²⁴³ Hurst C et al. (2002) *Manual of environmental microbiology*. Washington DC: American Public Health Association. 184, 186-188.

²⁴⁴ Heymann D. (Ed.) (2004) *Control of communicable diseases manual*. Washington, DC: American Public Health Association, pp. 138-141, 230-231, 383-385.

²⁴⁵ Eaton A et al. (2005) *Standard methods for the examination of water and wastewater*. Washington, DC: American Public Health Association, 9-1, 9-28 thru 9-31, 9-168.

Organism	Illness	Route of Infection	Resistant To Chlorine	Environmental Biofilm Amplification	Test Method
Pseudomonas Aeruginosa¹	<ul style="list-style-type: none"> Hot tub Folliculitis Conjunctivitis Pneumonia Swimmer's Ear Gastroenteritis Hip and Knee joint replacement infections, replacement heart valve infections Conjunctivitis Pneumonia 	<ul style="list-style-type: none"> Skin Eyes Inhalation Ears 	<ul style="list-style-type: none"> Yes when planktonic² Yes when sessile in biofilms 	Yes	<ul style="list-style-type: none"> APHA Standard Method 9213 E-F APHA Standard Method Rapid PCR test available
Enteric Bacteria	<ul style="list-style-type: none"> Legionnaires' Disease, Pontiac Fever Hip and Knee joint replacement infections, replacement heart valve infections 	<ul style="list-style-type: none"> Fecal/Oral Skin breaks Eyes Inhalation 	<ul style="list-style-type: none"> No when planktonic Yes when sessile in biofilm 	Yes	<ul style="list-style-type: none"> APHA Standard Method for Coliforms 9221 A-F APHA Standard Method 9260 A-L for specific pathogens APHA pathogen specific PCR test Bacteroides/Enterococci PCR tests under investigation by EPA to replace Coliforms
Legionella	<ul style="list-style-type: none"> Hypersensitivity pneumonitis Dermatitis Conjunctivitis Antibiotic resistant skin infection possibly fatal Primary amoebic meningoencephalitis (uncommon but high mortality rate) 	<ul style="list-style-type: none"> Inhalation Skin Breaks Eyes Skin Breaks Water accidentally inhaled in nose or pharynx 	<ul style="list-style-type: none"> Yes when planktonic³ Yes when sessile in biofilm 	Yes	<ul style="list-style-type: none"> APHA Standard Method 9260 J CDC/ISO Method is Gold Standard APHA Standard Method Rapid PCR test
Mycobacterium Avium complex (MAC)		<ul style="list-style-type: none"> Inhalation Skin Breaks 	<ul style="list-style-type: none"> Yes when planktonic Yes when sessile in biofilm 	Yes	<ul style="list-style-type: none"> APHA Standard Method 9260 M Rapid PCR
Staphylococcus aureus & Methicillin resistant Staph aureus (MRSA)		<ul style="list-style-type: none"> Eyes Skin Breaks 	<ul style="list-style-type: none"> No when planktonic Yes when sessile in biofilm 	Yes	<ul style="list-style-type: none"> APHA Standard Method 9213 B 6 and 7 Rapid PCR test
Naegleria fowleri		<ul style="list-style-type: none"> Water accidentally inhaled in nose or pharynx 	<ul style="list-style-type: none"> Yes when planktonic 	Yes	<ul style="list-style-type: none"> APHA Standard Method PCR test

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Organism	Illness	Route of Infection	Resistant To Chlorine	Environmental Biofilm Amplification	Test Method
Acanthamoeba	<ul style="list-style-type: none"> • Conjunctivitis and Keratoconjunctivitis (may cause blindness particularly in contact lens wearers) 	<ul style="list-style-type: none"> • Eye, skin, mucous membranes 	<ul style="list-style-type: none"> • Yes when sessile in biofilm 	Yes	<ul style="list-style-type: none"> • APHA Standard Method 9711 C
Cryptosporidium and Giardia	<ul style="list-style-type: none"> • Gastroenteritis • Biliary Tract Infections • Reactive Arthritis 	<ul style="list-style-type: none"> • Fecal/Oral • Inhalation • Inhalation 	<ul style="list-style-type: none"> • Cysts are resistant in planktonic and sessile forms 	Yes	<ul style="list-style-type: none"> • Standard Method 9711 B • APHA PCR test
Adenoviruses	<ul style="list-style-type: none"> • Conjunctivitis • Gastroenteritis 	<ul style="list-style-type: none"> • Eyes • Fecal/Oral 	<ul style="list-style-type: none"> • No 	Unknown	<ul style="list-style-type: none"> • Cell culture • PCR
Enteroviruses	<ul style="list-style-type: none"> • Gastroenteritis • Viral meningitis 	<ul style="list-style-type: none"> • Fecal/Oral 	<ul style="list-style-type: none"> • No 	Unknown	<ul style="list-style-type: none"> • APHA Standard Method 9510 • EPA Method 1615 • EPA Method 1615 • RT-PCR Methods
Noroviruses	<ul style="list-style-type: none"> • Gastrointestinal 	<ul style="list-style-type: none"> • Fecal/Oral 	<ul style="list-style-type: none"> • No 	Unknown	<ul style="list-style-type: none"> • APHA Standard Method 10750 • PCR tests available for species identification
Helminths and Roundworms	<ul style="list-style-type: none"> • Ascariasis • Baylisascariasis 	<ul style="list-style-type: none"> • Fecal/Oral 	<ul style="list-style-type: none"> • Cysts are resistant in planktonic and sessile forms 	Yes	<ul style="list-style-type: none"> • APHA Standard Method 10750 • PCR tests available for species identification
Fungi	<ul style="list-style-type: none"> • Ringworm 	<ul style="list-style-type: none"> • Skin 	<ul style="list-style-type: none"> • Spores are resistant 	Yes	<ul style="list-style-type: none"> • Culture and PCR tests

“This information is distributed solely for the purpose of pre-dissemination public comment under applicable information quality guidelines. It has not been formally disseminated by the Centers for Disease Control and Prevention. It does not represent and should not be construed to represent any agency determination or policy.”

Table 4.7.3.9 Notes:**M&T**

1. NOTE: a) Many elderly and/or immuno-compromised people use hot tubs making them more susceptible to disease; b) *P. aeruginosa* can be resistant to CHLORINE and is found in biofilm; c) Hot tub folliculitis is the most common illness associated with hot tubs; and d) Coliform testing is not an indication of *P. AERUGINOSA* contamination; e) Since this is a non-reportable disease, we have no information on the incidence of this disease.
2. Grobe, Wingender, & Flemming, 2001; Price, 1988; Clements, 2000.
3. Muraca, Stout, & Yu, 1987; Clements, 2000.

It is not feasible or cost effective to test for all infectious organisms. Therefore MAHC Annex Table 4.7.3.9 identifies those organisms which have readily available test methods and/or cause illnesses that are common, very serious, or fatal. It is important to note that these test methods may not allow for rapid remediation, decision making, or public health intervention on a timely basis.

The Heterotrophic Plate Counts (HPC) method has not been included in the list of microbial water quality tests in MAHC Annex Table 4.7.3.9. While HPC data are generally a good indicator of microbial water quality and efficacy of POOL operations (e.g., water treatment), this parameter has been reported to show no correlation to the presence of *Legionella*²⁴⁶, planktonic pathogens²⁴⁷, or the presence of biofilm²⁴⁸. HPC tests (as do all culture tests) under-report the actual concentration of viable bacteria. Therefore, it is recommended that the use of this test be restricted for assessing the level of planktonic, non-pathogenic bacteria only. HPC data are not sufficient to assess the public health risk of POOLS, SPAS, and waterparks,²⁴⁹.

Since the MAHC is intended to be a living document with changes anticipated as our knowledge increases, it is prudent to acknowledge that a paradigm shift is occurring in the world of microbiology that likely will impact how pathogen testing will be conducted and interpreted in the future. Culture tests are gradually being replaced with culture-independent test methods such as Polymerase Chain Reaction (PCR) testing and microarray testing. Years ago when PCR was first used commercially the cost of the tests was prohibitively expensive. Now test costs have decreased and are competitive with culture dependent tests. A recent development is the commercialization of microarray testing which can screen for the presence of a wide variety of bacterial and viral pathogens without the need for an ISOLATION step. However, the costs associated with microarray testing are prohibitively expensive as of this publication.

²⁴⁶ Hodgson M, and Casey B. (1996) Prevalence of *Legionella* bacteria in building water systems. In *IAQ 96. Paths to Better Building Environments*. Conference of the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Atlanta.

²⁴⁷ Paulson D. (Ed.) (2010) Applied biomedical microbiology: A biofilms approach. Chapter 8: Matias F, et.al., Disinfection and its influence on biofilm ecology . Chapter 9: Goeres D, Understanding the importance of biofilm growth in hot tubs. Boca Raton, FL: CRC Press.

²⁴⁸ Donlan RM and Costerton JW. (2002) Biofilms: survival mechanisms of clinically relevant microorganisms. *Clinical Microbiology Review*, 15, 167-93.

²⁴⁹ Costerton JW. (2007) The biofilm primer. Germany: Springer-Verlag.1-97.

EPA is re-evaluating the use of culture-based fecal indicator bacteria (FIB) tests in recreational water testing (i.e., total and fecal coliforms, *E. coli* and *Enterococcus*) and is researching the use of PCR for *Bacteroides* and *Enterococcus* testing as a possible replacement for these culture tests. Two of the most compelling reasons for this re-evaluation are:

- Incubation times for culture tests prevent quick decision-making to minimize public exposure to water with a potentially elevated disease risk, and
- Molecular tests are generally considered to have higher specificity (lower false positive rates) than traditional culture tests.

PCR can be a good method for investigating whether pathogenic microbes were present in AQUATIC VENUES since the technique detects the DNA of pathogens regardless of whether they are live, dead, or viable-but-not-culturable. Another benefit is that PCR culture tests can be completed in hours versus days. However, while PCR can be effective for determining whether pathogens have been present in an AQUATIC VENUE, the technique is less effective as a measure of DISINFECTION effectiveness since it detects DNA from both viable and non-viable organisms. New techniques, such as the use of propidium monoazide (PMA) have been reported to enable PCR to characterize the viability status of microorganisms, so in the future PCR may be an effective option for DISINFECTION studies²⁵⁰.

4.7.4 Water Replenishment

R&F

Water Replenishment System

R&F

A WATER REPLENISHMENT SYSTEM allows for POOL water to be removed from the POOL and properly disposed of so that it can be replaced with fresh water containing lower concentrations of dissolved CONTAMINANTS. A WATER REPLENISHMENT SYSTEM should be used to control the dissolved organic CONTAMINANT concentrations (e.g., sweat, oils, chlorination by-products, and urine) and dissolved inorganics (e.g., salts and metals) because POOL filtration systems are not effective at removing dissolved CONTAMINANTS.

4.7.4.1 Local Authority

R&F

AQUATIC VENUE waste streams (including filter backwash water and POOL drainage water) should be discharged through an air gap to sanitary sewers, storm sewers, drain fields, or by other means, in accordance with local municipal and building official recommendations including obtaining all necessary permits. The discharge should occur in a manner that does not result in a nuisance condition.

Each waste line should have a unique air gap. Waste lines from different sources (e.g. POOL, SPA, overflow, sump pump, etc.) should not be tied together, but multiple waste lines may discharge into a common sump or receptacle after an air gap.

²⁵⁰ Brescia CC et al. (2009) *Cryptosporidium* propidium monoazide-PCR, a molecular biology-based technique for genotyping of viable *Cryptosporidium* oocysts. *Applied and Environmental Microbiology*, 75:6856-6863.

4.7.4.2 Discharge and Measure**R&F**

A means of intentionally discharging and measuring the volume of discharged POOL water (in addition to the filter backwashing system) should be installed and designed to discharge a volume of water of up to 4 gallons (15 L) per BATHER per day per facility through an air gap. Water replacement or replenishment at a rate of 8 gallons (30 L) per BATHER per day per AQUATIC VENUE^{251,252,253} have been widely used. PWTAG²⁵⁴ states that as much as half of the recommended amount could be associated with filter backwashing. There does not appear to be any research to support the use of the 30L/day/BATHER number used abroad. So, since 4 gal/day/BATHER is roughly half of this amount (and typically met by filter backwashing alone), it seems like a reasonable place to start. A requirement could be made once the science is there to support a higher or lower value. With a WATER REPLENISHMENT SYSTEM in place, AQUATIC FACILITY operators will be able to experiment with higher WATER REPLENISHMENT rates to obtain better water (and indoor air) quality . It should also be easy to comply with any future regulations related to WATER REPLENISHMENT as only the flow rate would require adjustment. WATER REPLENISHMENT for a large water park would be based on the number of BATHERS in the entire AQUATIC FACILITY (not the total number swimming in a particular AQUATIC VENUE on a given day since most PATRONS are expected to distribute their BATHER LOAD over a range of AQUATIC VENUES and/or rides on a given day). However, WATER REPLENISHMENT should be proportional to the number of BATHERS in each individual treatment system. It would not be allowable to send to waste all of the water from the WAVE POOL and none from the other attractions (unless the water was shared through a combined AQUATIC VENUE treatment system).

Alternate Systems**R&F**

The code allows for use of alternate systems to meet the intent for removal of organic compounds and salts. Currently, the Technical Committee is not aware of such systems.

²⁵¹ Pool Water Treatment Advisory Group (PWTAG). Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.

²⁵² World Health Organization (WHO). Guidelines for Safe Recreational Water Environments: Vol. 2- Swimming Pools and Similar Environments. 2006. WHO Press, Geneva, Switzerland. ISBN: 9241546808.

²⁵³ Gregory R. Bench-marking Pool Water Treatment for Coping with Cryptosporidium. Journal of Environmental Health Research. 2002;1(1):11-18.

²⁵⁴ Pool Water Treatment Advisory Group (PWTAG). Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.

4.7.5 Spas

4.7.5.1	General	R&F
4.7.5.2	Flow Rates / Turnover Times	R&F
4.7.5.3	Filtration System Inlets	R&F
4.7.5.4	Jet System Inlets	R&F

4.8 Decks and Equipment

4.8.1 Decks

4.8.1.1	General Standards for All Decks	D&C
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4.8.1.1.2 Lifeguard Placement and Safety Considerations LG

See MAHC Section 4.6.5.1 and 6.3.2.1.1 for operational considerations in design.

4.8.1.1.2.1 Deck Clearance LG

Four feet of clearance would allow for safe movement of a QUALIFIED LIFEGUARD roaming or for extrication in case of an emergency. This is consistent with the design guidance of the MAHC.

4.8.1.1.2.2 Access Points LG

In locations where PERIMETER DECK is non-contiguous and the clearance is not at least 4 feet, such as where fencing is provided around elevated POOL edges and LAZY RIVERS, locations for lifeguards to safely access the POOL edge should be required. This facilitates a safe entry rather than climbing over any fence or other obstruction.

4.8.1.1.2.3 Patron Zone Surveillance LG

Designers have historically added AQUATIC FEATURES that are not readily visible on a site plan nor are their effects self-evident until installed during construction. This could result in additional lifeguards to facilitate zone coverage or create small blind spots. For this reason, this line item was added for the designer to consider.

4.8.1.1.6 Concrete Decking D&C

See American Concrete Institute Standards Reference 302.1 R-80, Guide for Concrete Floor and Slab Construction.

4.8.1.2	Standards for Perimeter Decks	D&C
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4.8.1.2.1 Impervious D&C

The term "PERIMETER DECK" refers to the area around and immediately adjacent to the POOL. This area is the wettest area of the DECK and extends out from the edge of the POOL a maximum of 4 feet (1.2 m) or out to DECK drains, whichever is farther. Finish

materials for the PERIMETER DECK must be suitable for the POOL environment, non-toxic, and substantially impervious. See MAHC Section 4.8.1.4 and comments.

4.8.1.3 Drains

D&C

4.8.1.3.1 Slope

D&C

MAHC Table 4.8.1.2 was arrived at by distilling the preponderance of existing state CODES and established STANDARDS. Fundamentally, these sources all seek to eliminate standing water from the DECK, typically recognizing that smoother surfaces convey water more efficiently than rougher ones. Relating slopes to texture, rather than specific materials, provides the ability for any otherwise suitable DECK material or finish to be considered by the adopting jurisdiction.

There is an inherent conflict in sloping of DECKS. Steeper slopes provide more construction tolerance and surety in conveying water, particularly in active soil conditions. Shallow slopes are required to meet accessibility guidelines – particularly for cross-slopes. It is the intent of this section to encourage positive and proper drainage without running afoul of accessibility guidelines.

4.8.1.3.3 Cross Connection Control

D&C

Consult local AHJ regarding specific chemical handling and use to properly dispose, including discharge to the watershed or sanitary sewers where appropriate.

4.8.1.3.3.1 No Drain

RM

This requirement prevents sewage from backing up into the AQUATIC VENUE water. This isolates the treated system and does not allow mixing of other sources of water that could contaminate.

4.8.1.4 Materials/Slip Resistance

RM

At this time, ASTM is developing a STANDARD to define a method to test for slip resistance.

4.8.1.4.2 Slip Resistance

D&C

While much research has been done and several STANDARD tests created for defining “slip resistance”, no industry STANDARDS exist specifically related to aquatic environments. Most studies have been performed in the interest of SAFETY in employment, providing guidance with respect to work surfaces and footwear. The most commonly accepted test for slip resistance, using a device called the James Machine (ASTM D2047), is not suitable for testing wet surfaces, and is not portable for testing in the field²⁵⁵.

4.8.1.4.3 Carpet

D&C

²⁵⁵ Ceramic Tile Institute. Endorsement of improved test methods and slip prevention standards for new flooring. Accessed 07/30/2013 from <http://www.ctioa.org/reports/cof16.html>.

Carpet and artificial turf have been found to be inappropriate finish materials for the wettest area immediately around the POOL, i.e. PERIMETER DECK. Although the materials that carpet is manufactured from are durable and do not support mold growth, when they are installed over a relatively impermeable surface, water flows very slowly through the carpet. Soil and CONTAMINANTS entering into the carpet are not easily removed. Since the carpet stays wet longer, and soil and CONTAMINANTS remain in the carpet mold and algae growth is observed. Therefore carpeting is not an acceptable finish material in the wet PERIMETER DECK.

Finish materials for the PERIMETER DECK should not block DECK drains or impair water flowing to DECK drains.

Carpeting can be installed beyond the DECK drains, i.e. DRY DECK.

4.8.1.4.4 Wood

D&C

Properly treated or composite wood materials may be a suitable material for POOL DECKS provided all other DECKING requirements are maintained. Fasteners must be regularly inspected to ensure structural integrity and that all heads are flush or recessed into the DECK surface.

4.8.1.4.5 Dry Deck

D&C

Regional materials, local practices and particular facility design intentions vary widely with respect to DRY DECK. This paragraph intends to provide the opportunity for regulatory oversight of DRY DECK, without limiting these variables best understood by AHJ.

4.8.1.4.6 Landscaping

D&C

It is acknowledged that landscaping near AQUATIC VENUES is not an uncommon practice in enhancing an AQUATIC VENUE environment. Landscape materials themselves and the design of special POOL types vary so widely as to require special consideration with respect to landscaping. This paragraph intends to provide the opportunity to allow landscaping, but only through the lens of the local authority.

The landscaping materials are not intended to be placed in the wet PERIMETER DECK area. It is assumed here that the POOL DECK will be designed and sloped to prevent drainage from landscaping materials from reaching the POOL.

For an outdoor AQUATIC VENUE, it is not possible to prevent wind from moving dirt, bugs, plant material, etc. from landscape material around and perhaps into the AQUATIC VENUE. The landscape designer must consider the type and location of landscape materials placed inside or outside of an outdoor AQUATIC VENUE ENCLOSURE.

Textured Surface

RM

The walking surface should not be rough so as to cause injury or discomfort to BATHERS.

ANSI defines where a trip hazard is considered as a level change that is greater than ¼ inch. Other definitions include an abrupt or unexpected level change in surfaces.

4.8.1.5 Deck Size/Width RM

Traditional AQUATIC VENUES should be surrounded by clear DECK space to allow for operational flow (foot traffic) as well as space to perform in the event of an emergency situation. Non-traditional AQUATIC VENUES such as LAZY RIVERS, WAVE POOLS, etc. are not required to have clear space around due to the need to control access by providing a BARRIER to block access into unapproved entry areas. Both guarded and unguarded AQUATIC VENUES should have the same clear space requirements.

4.8.1.5.1.1 Width D&C

The 4 foot unobstructed DECK area is intended to ensure a minimum clear area for emergency access and care around the POOL. Examples of obstructions include but are not limited to INFINITY EDGES, ADA transfer walls, and curbs.

4.8.1.5.1.2 Perimeter Decking D&C

Most POOLS require continuous DECKS in order to safely accommodate circulation of all users of the AQUATIC VENUE.

4.8.1.5.1.3 Unguarded Aquatic Venues D&C

Unguarded AQUATIC VENUES require special consideration must be provided for DECK access.

- Option 1 assures the entire perimeter is available for assistance.
- Option 2 allows for incorporation of leisure amenities and AQUATIC VENUE features such as “INFINITY EDGES” and landscaping, while maintaining assurance that the entire POOL can be reached with STANDARD SAFETY equipment.

Individual requests for variance could accommodate different designs.

4.8.1.5.2 Fixed Equipment D&C

4.8.1.5.3 Circulation Path D&C

4.8.1.6 Wing Walls or Peninsulas D&C

4.8.1.6.1 No Perimeter Deck D&C

A WING WALL or PENINSULA is intended to provide separation of different areas in a POOL. The separated areas may have differing uses, flow rates, currents, or water depths.

4.8.1.6.2 Perimeter Overflow System D&C

The MAHC Committee defines WING WALLS as interior elements of the POOL and interior to the perimeter overflow system, so did not feel it was appropriate to say that WING WALLS longer than some specified length should require perimeter overflow. It would be a function of the width of the WING WALL as to whether or not it can be properly

constructed. If the POOL has a gutter system, it would probably need 4 feet (1.2.m) of width to get a normal trough on either side. SKIMMERS could be achieved for narrower walls because they could be staggered.

4.8.1.6.3 Pool Perimeter D&C

4.8.1.6.3.1 Calculating D&C

WING WALLS do not contribute to the overall POOL perimeter so should not be included in AQUATIC VENUE perimeter calculations that are used as part of multiple critical design calculations.

4.8.1.6.4 Normal Operating Water Level D&C

4.8.1.6.5 Deck Drainage D&C

The MAHC technical committee did not feel that DECK drains would be required on WING WALLS since they are considered part of the POOL and not subject to regular foot traffic. As for DECK level POOLS, the WING WALLS would be at or below water level making drains impractical.

4.8.1.7 Islands D&C

4.8.1.7.7 Minimum Clearance D&C

A 7 foot (2.1 m) minimum clearance overhead is required since it is consistent with requirements of building code minimum ceiling clearances.

4.8.1.8 Heated Decks D&C

4.8.1.8.1 Freeze Protection D&C

Heated DECKS are occasionally used in cold climates to provide pedestrian paths to and around outdoor heated AQUATIC VENUES. This section provides that when heated DECKS or snow-melt systems are provided, a minimum slope must be uniformly provided. Clear delineation is required because icy areas and/or pathway edges near otherwise DRY DECK poses an unsafe condition.

4.8.1.9 Hose Bibbs D&C

4.8.2 Diving Boards and Platforms D&C

4.8.2.1 Diving Envelope D&C

4.8.2.1.1 Conforms D&C

This code is designed to encourage POOLS to be built to the STANDARDS of the agency that will certify the diving at the AQUATIC FACILITY. The code dimensions are purposely a compilation of the most conservative STANDARDS of diving envelope dimensions and are in no way intended to supersede the certifying agencies dimensions, but instead are intended to be used only when there is no certifying agency for the AQUATIC FACILITY.

Since NCAA, USA Diving, and FINA do not have STANDARDS for boards less than 1-meter in height, the State of Michigan table (R325.21.33, Table 1) was revised to the most conservative STANDARD found for 0.5-meter and 0.75-meter boards. These minimum dimensional requirements were then dictated to be more conservative in certain instances based largely on interpolations.

Concerning use of diving boards higher than 1-meter, these boards are not recommended for non-competitive use. However, if the boards are constructed to this code or NCAA standards, then non-competitive use can be allowed under careful adult supervision or with QUALIFIED LIFEGUARDS on duty. However, non-conformance with these STANDARDS is unsafe for recreational diving purposes.

4.8.2.2 Steps and Guardrails D&C

4.8.3 Starting Platforms D&C

4.8.3.1 Conform to Standard Codes D&C

The intent is to require a minimum 4 ft. (1.2 m) water depth under the starting platform and the oversight of an aquatics governing body (e.g. FINA, USA Swimming, NCAA, NFSHSA, YMCA, etc.) or a coach or instructor. FINA, USA Swimming, NFHS, and the NCAA allow 4 feet (1.22 m) at starting platforms.

Although there are some national data on spinal cord injuries (SCIs) in general, data on diving-specific SCIs are limited, particularly for SCIs involving public POOL-related competition diving.

Spinal Cord Injury Data

General data on spinal cord injuries: For SCIs in general, approximately 40 SCIs/million population occur each year in the US (about 12,400 injuries for 2010) with approximately 4.5% related to diving injuries.²⁵⁶ SCIs are a catastrophic public health problem leading to disability and decreased life expectancy²⁵⁷ with a large economic and social burden for those that suffer the injury^{258,259}.

Non-DECK level diving, competition diving, and SCIs: Data related to SCIs occurring as a result of competition diving off starting platforms are limited. Since starting platforms are several feet above the POOL, the entering velocity of swimmers is greater than for DECK level diving making it more difficult to alter trajectory once executed²⁶⁰. One large study investigated 74 SCIs in non-competitive divers occurring with use of springboards

²⁵⁶ DeVivo MJ. Epidemiology of traumatic spinal cord injury: trends and future implications. Spinal Cord. 2012 May;50(5):365-72.

²⁵⁷ Blanksby BA, et al. Aetiology and occurrence of diving injuries. A review of diving safety. Sports Med. 1997;23(4):228-46.

²⁵⁸ Blanksby BA, et al. Aetiology and occurrence of diving injuries. A review of diving safety. Sports Med. 1997;23(4):228-46.

²⁵⁹ Borius PY, et al. Cervical spine injuries resulting from diving accidents in swimming pools: outcome of 34 patients. Eur Spine J. 2010 Apr;19(4):552-7

²⁶⁰ Albrand OW, Walter J. Underwater deceleration curves in relation to injuries from diving. Surg Neurol. 1975;4(5):461-4.

and/or jumpboards; 45% of the POOLS were public²⁶¹. Of these injuries, 12.2% occurred in water <4 ft; 66.2% occurred in water <5 ft.; 94.6% occurred in water <6ft. All SCIs occurred in water of <7 ft. The MAHC requires that starting blocks be removed, if possible, or blocked off to prevent recreational divers from using them when not in use by competitive swimmers.

Data demonstrates that competitive swimmers can be trained to perform shallow water dives from starting blocks to reduce the risk of SCIs^{262,263,264}. As a result, competitive aquatics governing bodies (e.g., Federation Internationale de Natation (FINA), U.S.A. Swimming, National Collegiate Athletic Association (NCAA), National Federation of State High Schools Associations (NFSHSA), YMCA) allow starting blocks to be placed over water as shallow as 4 ft (1.2 m) in depth as long as competition is conducted under the auspices of the governing body or by a coach or instructor. A progressive training regimen can be used so that diver training is conducted in deeper water until the diver has mastered the technique before the certified personnel approve their starting block entries into shallower depths²⁶⁵. However, further data are needed on the adequacy of an intervention, like training, that relies on correctly performing a technique to prevent injury; aquatics governing bodies state they have not documented injuries since this progressive training regimen has been adopted. However, it is noted that high speed video of competing athletes during competition dives from starting platforms illustrates that about 3% of athletes diving into 4 feet of water²⁶⁶ (the POOL had the minimum depth recommended for athletes using starting blocks) touched the bottom, nearly half approach within 0.5 meters of the bottom, and over half exceeded head speed thresholds deemed possible to cause severe head trauma; there was some anecdotal information suggesting some divers touched intentionally. Conversely, filming of athletes diving into 7.5 ft of water (the POOL studies exceeded Olympic competition depths of 6.5 feet below starting platforms) showed that very few swimmers approach to within even 1 meter of the POOL bottom²⁶⁷. These data suggest that injury risk from using starting platforms is likely to be higher for older, presumably heavier, or inexperienced divers, particularly when diving into shallower depths.

Future Directions and Research:

D&C

The MAHC recommends expanded analysis of national and other SCI data sets that might further inform this discussion. Future analysis of national databases should be undertaken, if possible, to assess the occurrence of SCIs in competitive swimmers and platform heights and water depths at which the injury occurred. Historical analysis and

²⁶¹ Gabrielsen MA, Spivey M. Diving injuries: The etiology of 486 case studies with recommendations for needed action. 1990. Nova University Press, Ft. Lauderdale, FL.

²⁶² Blitvich JD, et al. Dive depth and water depth in competitive swim starts. J Swimming Res. 2000;14:33-39.

²⁶³ Cornett AC, et al. Start depth modification by adolescent competitive swimmers. Int J Aquatic Res Educ. 2012;6:68-79.

²⁶⁴ White JC, et al. Competitive swimmers modify racing start depth upon request. Int J Aquatic Res Educ. 2011;5:187-198.

²⁶⁵ Cornett AC, et al. Teaching competitive racing starts: Practices and opinions of professional swim coaches. Int J Aquatic Res Educ. 2012;6:156-170.

²⁶⁶ Cornett AC, et al. Racing start safety: Head depth and head speed during competitive starts into a water depth of 1.22m. Int J Aquatic Res Ed. 2010;4:365-378.

²⁶⁷ Cornett AC, et al. Racing start safety Head depth and head speed during competitive starts into a water depth of 2.29m. Int J Aquatic Res Ed. 2011;5:14-31.

peer-reviewed publication of data or reports collected by aquatics governing groups on SCIs and other diving injuries would also be important to understand POOL-specific diving injuries occurring in competitive swimmers and the efficacy of current progressive training or other interventions.

4.8.4 Deck Slides

4.8.5 Lifeguard and Safety Related Equipment

4.8.5.1 Safety Equipment Required at all Aquatic Facilities LG

4.8.5.1.1 Emergency Communication Equipment LG

A communication device is required in the Operations section, but it also needs to be considered in the design so the designer can plan for the wiring for such devices. Consider larger facilities or other types of facilities who may have a phone in the nearby building. Consider a telephone labeled with location of phone/address. Some facilities may be so equipped to properly respond to an event and phones may not be required. Large AQUATIC FACILITIES with lifeguard/trained response may not need phones installed everywhere. The intent is for BATHERS to have access to a phone to call for help when help is not necessarily part of the AQUATIC FACILITY operation.

QUALIFIED LIFEGUARDS or other emergency response staff are to be trained and may have communication devices such as whistles or radios which initiate their emergency response which includes the ability to contact outside emergency personnel when necessary. Often AQUATIC VENUES can be at a distance from support personnel and the designer should consider methods for personnel to communicate whether via radio, telephone, intercom, or other method. For alternate communication systems or devices, the intent is that an emergency phone or communications system or device is immediately available to PATRONS from all AQUATIC VENUES within an AQUATIC FACILITY. Some alternate communication systems might include a handset or intercom system to a location that is constantly manned whenever the AQUATIC VENUE is open for use (e.g. a front desk at a hotel, the check in desk at a fitness club, or other continuously manned location); a commercial emergency contact device that connects to a MONITORING service, or directly to 911 dispatch; or devices that alert multiple staff on site when activated (e.g. pagers systems, cellular telephone systems and radio communication alert systems). (Also see MAHC 5.8.5.2.1)

4.8.5.1.2 First Aid Equipment

4.8.5.1.3 Signage

4.8.5.2 Safety Equipment Required at Aquatic Facilities with Lifeguards

4.8.5.2.1 Lifeguard Chair and Stand Placement LG

This line item refers to only those chairs that are permanently installed and does not indicate that a permanent chair or stand is required. The location of the chairs must give

the QUALIFIED LIFEGUARD complete visibility to all parts of the zone of PATRON surveillance. The number of chairs is determined by the ability to provide surveillance of the AQUATIC VENUE by creating zones of PATRON surveillance. It is intended that the designer should be working with an aquatic consultant or the owner/operator to make sure the location of chairs and stands allow for clear line of sight.

4.8.5.2.2 Lifeguard Chair and Stand Design

LG

Chairs and stands are exposed to elements; therefore, they should be made to withstand the environment. The intent for such a chair is to facilitate better surveillance and such the chair should be elevated sufficiently above the heads of BATHERS to have a better view and combat glare. Considerations for the SAFETY of QUALIFIED LIFEGUARDS using these chairs should include access and egress as well as BARRIERS to unauthorized access if installed at an elevation.

4.8.5.2.3 UV Protection for Chairs and Stands

LG

Protection from ultraviolet radiation exposure can include a shade attached to the stand, a shade structure external to the stand, or other types of shade such as surrounding features. The designer should consider which method will be employed to provide UV protection for the stand.

4.8.6 Barriers and Enclosures

4.8.6.1 General Requirements

D&C

4.8.6.2 Construction Requirements

D&C

4.8.6.2.1 Local Code

D&C

Many POOL CODES refer to a 4 inch (100 mm) sphere in the body of the code. From a Building Code perspective, this is not consistently enforced and they don't regulate that small of an opening. Building Code allows STANDARD 2-1/4 inches mesh fencing and is not necessarily specific for AQUATIC VENUE. Building Code typically dictates minimum height and proximity to property lines - unless it's a fall issue. With POOLS, we are mainly concerned with discouraging unauthorized entry / break-ins.

4.8.6.2.4 Building Emergency Exit

D&C

It is the intent of this section to prevent emergency egress routes from exposing building occupants to unguarded AQUATIC VENUE areas. It is not the intent of this section to permanently segregate multiple AQUATIC VENUES on the same site. Temporary or seasonal ENCLOSURES (properly maintained and employed) may be used to segregate paths of egress from a building or adjacent AQUATIC VENUE to SAFETY. For example, where a seasonal outdoor AQUATIC VENUE is operated in conjunction with a year-round indoor AQUATIC VENUE, a seasonal exit pathway separation ENCLOSURE may be used to maintain exiting in the off-season. During the outdoor swim season (the outdoor AQUATIC VENUE is in operation), it is acceptable to egress via the AQUATIC VENUE DECK TO EXIT GATES.

4.8.6.2.7 Height**D&C**

The MAHC Committee discussed this issue at length. The prevailing "BEST PRACTICE" in the industry is for 4 foot (1.22 m) high fencing around unguarded AQUATIC VENUES. However, the Steering Committee decided to make the BARRIER height the same for all POOLS (6ft or 1.8 meters) since 4ft fences are scalable even with smaller mesh. Generally, even unguarded AQUATIC VENUES have some hours of use and these POOLS also need to discourage use outside of operational hours by youth and others. Their collective logic was that if an AQUATIC VENUES is designed for unsupervised use at all times then there is no real advantage to a fence higher than 6 foot (i.e., 8 foot or taller).

4.8.6.2.7.3 Other Barriers**D&C**

The 42" (1.1 m) BARRIER height is consistent with STANDARD building CODE requirements for a guardrail, which serves substantially similar purposes. This height provides for consistency across CODES for like appurtenances.

4.8.6.3 Gates and Doors**D&C****4.8.6.3.6 Absence of Local Building Codes****D&C**

This section is intended to address large AQUATIC FACILITIES where there may either be multiple AQUATIC VENUES, multiple grade elevations, or both. EXIT GATES must be provided to permit adequate emergency egress. For example, an AQUATIC FACILITY with 10 AQUATIC VENUES split between different grade elevations should have the required number of exits spaced reasonably around the perimeter and not all at one grade elevation.

4.8.6.4 Indoor Aquatic Venues**D&C****4.8.6.4.3 Indoor and Outdoor Aquatic Venues****D&C**

If a seasonal AQUATIC VENUE is on the same property as a AQUATIC VENUE operated outside of that same season, PATRONS need to be prevented from accessing the closed AQUATIC VENUES for SAFETY.

4.8.6.4.4 Wall Separating**D&C**

6 feet 8 inches (2. m) minimum clearance overhead is required since it is consistent with requirements of building code minimum doorway clearances. Materials that do not pose a possibility of physical injury may be suspended from the structure to help contain the indoor NATATORIUM environment.

4.8.6.5 Multiple Aquatic Venues**D&C****4.8.6.5.2 Wading Pools****D&C**

Rationale of 24" (0.6 m) deep rule is that if adjacent water is not substantively deeper than the WADING POOL, there is no need to segregate the two. If it is the only AQUATIC VENUE within the facility, then normal fencing and perimeter ENCLOSURE requirements would apply. If WADING POOLS are a part of a larger facility with other types of AQUATIC VENUES, then the requirements proposed in MAHC Section 4.12.9.2 would apply.

4.8.7 Aquatic Venue Cleaning System

The MAHC Committee encourages draining SPAS for cleaning. A vacuum likely would not be required for very small AQUATIC VENUES, such as SPAS less than 75 square feet. A simple wall brush with pole can adequately and efficiently clean the floor.

4.8.7.1 No Hazard

D&C

Pumps shall not exceed 3 horsepower because the suction hydraulic of a larger pump through the small vacuum tubing would force the pump to operate at unacceptable hydraulic conditions. Strong suction forces provide a greater risk for bodily harm in the event of a vacuum system mishap.

POOL vacuum systems must use suitably-sized pumps, proper diameter vacuum hoses, and reasonable hose lengths to provide optimum hydraulics for vacuuming operations. Conventional suction requirements call for a maximum 15 feet (4.57 m) of water at a flow of 4 GPM per lineal inch of suction cleaner head for the total suction head loss.

4.8.7.7 GFCI Connection

D&C

Not allowing extension cords prevents the possibility that the high voltage power supply unit has enough cord to potentially be dragged into the POOL causing a potential SAFETY risk.

4.8.7.8 Power Cord

D&C

The power cord length needs to be shorter than the distance between the receptacle and the edge of the POOL in order to prevent the power supply from accidentally entering the POOL water while connected.

4.9 Filter/Equipment Room

4.9.1 Equipment Room

D&C

4.9.1.1 General Requirements

D&C

4.9.1.1.3 Opening

D&C

Building code speaks to minimum door widths from an egress standpoint which is typically narrower. The height is consistent with building code requirements.

4.9.1.2 Construction

D&C

- See NEC Art. 110-26 Minimum clearances.
- See INTERNATIONAL MECHANICAL CODE Sec. 304.1.
- See NFPA 54 National Fuel Gas Code Sec. 8.1.2.

4.9.1.3 Electrical

D&C

4.9.1.4 Ventilation

D&C

4.9.1.4.1 Code Conformance

D&C

- See INTERNATIONAL MECHANICAL CODE Sec. 502.

4.9.1.5 Markings

D&C

4.9.1.5.1 Piping Identified

D&C

Pipes may be color coded according to use with either labels or a reference chart; directional arrows with permanent labeling on the pipes; or by other means deemed suitable by the AHJ.

4.9.1.6 Equipment Rooms Containing Combustion Equipment

D&C

Installed

D&C

No code language exists for this section since the MAHC defers to other CODES but the rationale for some of it is still included in the Annex

No items should be installed, nor shall STORAGE be planned for any items, within the minimum clearances of a COMBUSTION DEVICE, as defined by the manufacturer, or within the minimum clearances as defined the National Fuel Gas Code or other applicable code, whichever are greater.

- See INTERNATIONAL MECHANICAL CODE Sec. 304.1.
- See NFPA 54 National Fuel Gas Code Sec. 8.1.2.

Increased Ventilation

D&C

Rooms containing combustion equipment may be subject to requirements for increased ventilation and combustion-air intake, as specified by the National Fuel Gas Code or other pertinent CODES. The EQUIPMENT ROOM should be so constructed as to allow for the planned equipment, or should be modified as necessary.

Where an EQUIPMENT ROOM contains combustion equipment which uses equipment-room air for combustion, no other equipment should be so installed as to reduce the room air pressure beyond the acceptable air-intake pressure range for the combustion equipment.

- See INTERNATIONAL MECHANICAL CODE Sec. 701.

Noxious Gasses

D&C

All practical flames produce carbon monoxide or nitrous oxides. There is very little chance of being rid of both of them at the same time. Neither is good for human health. The key is to dilute combustion products and send them up the flue. This does not always work where equipment- room air pressure is lower than outdoor air pressure. Some COMBUSTION DEVICES work by natural draft (buoyancy of hot gases) and cannot tolerate any pressure difference. Other COMBUSTION DEVICES have higher pressure differences which they can overcome.

Where an EQUIPMENT ROOM contains combustion equipment which uses EQUIPMENT ROOM air for combustion, air-handling equipment should not use the room as a plenum. Exceptions may include where the combustion equipment is listed and labeled for the expected use, such installation shall be acceptable where approved by the AHJ.

- See INTERNATIONAL MECHANICAL CODE Sec. 701.

Plenum Room

D&C

A plenum room uses the EQUIPMENT ROOM as the intake duct for HVAC equipment. Thus, it will have a low air pressure while the HVAC equipment is operating. For a NATATORIUM, the incoming air would contain halogen compounds, e.g. chloramines, and thus should never be used as combustion air.

Where an EQUIPMENT ROOM contains combustion equipment which uses a draft hood, air-handling equipment should not use the room as a plenum. Exceptions may include where the combustion equipment is listed and labeled for the expected use, such installation shall be acceptable where approved by the AHJ.

- See INTERNATIONAL MECHANICAL CODE Sec. 701.

Lowered Room Pressure

D&C

In this situation, there is a tendency for the lowered room pressure to pull combustion products back down the flue into the room, and thus spread them everywhere.

Rooms containing combustion equipment are also subject to requirements for separation from chemical-STORAGE spaces.

4.9.1.7 Separation from Chemical Storage Spaces

D&C

Largely, building STANDARDS do not speak to AQUATIC VENUES.; for example, the dangers that chemical fumes pose to combustion equipment.

4.9.1.7.1 Equipment

D&C

4.9.1.7.1.1 Contaminated Air

D&C

Combustion equipment, air-handling equipment, and electrical equipment should not be exposed to air contaminated with corrosive chemical fumes or vapors.

- See ANSI/ACCA Manual SPS 2010 Sec 1-6.
- See NFPA National Fuel Gas Code (2002) Sec. 8.1.6
- See “Proper Venting of Gas Fueled Appliances”, Chimney Safety Institute of America, Plainfield, IN, 2010
- See “Instruction Sheet IV, Identifying and Correcting Burner Problems”, Propane Council, Washington, DC, 2010

4.9.1.7.1.2 Equipment Restrictions

D&C

Spaces containing combustion equipment, air handling equipment, and/or electrical equipment and spaces sharing air distribution with spaces containing such equipment shall not at the same time be used as CHEMICAL STORAGE SPACES. Exceptions may include equipment listed and labeled for use in that atmosphere shall be acceptable, where approved by the AHJ.

- See: INTERNATIONAL MECHANICAL CODE Sec. 304.1
- See: ANSI/ACCA Manual SPS 2010 Sec 1-6.

4.9.1.7.1.3 Isolated

D&C

Spaces containing combustion equipment, air-handling equipment, and/or electrical equipment and spaces sharing air distribution with spaces containing such equipment shall be isolated from CHEMICAL STORAGE SPACE air.

- See INTERNATIONAL MECHANICAL CODE Sec. 304.1
- See ANSI/ACCA Manual SPS 2010 Sec 1-6.

4.9.1.7.2 Doors and Openings

D&C

4.9.1.7.2.1 Between Equipment and Chemical Storage Spaces D&C

A door or doors should not be installed in a wall between such EQUIPMENT ROOMS and an interior CHEMICAL STORAGE SPACE.

- See INTERNATIONAL MECHANICAL CODE Sec. 304.1
- See ANSI/ACCA Manual SPS 2010 Sec 1-6.

4.9.1.7.2.2 No Openings

D&C

CHEMICAL STORAGE SPACE door(s) must not be left open. This is important to controlling air pressure ratios, keeping corrosive gases out of COMBUSTION DEVICES, and keeping children away from hazards.

There should be no ducts, grilles, pass-throughs, or other openings connecting such EQUIPMENT ROOMS to chemical-STORAGE SPACES.

- See INTERNATIONAL MECHANICAL CODE Sec. 304.1
- See ANSI/ACCA Manual SPS 2010 Sec 1-6.

4.9.1.7.2.3 Natatorium Air

D&C

Spaces containing combustion equipment, air-handling equipment, and/or electrical equipment and spaces sharing air distribution with spaces containing such equipment should be isolated from NATATORIUM air. Exceptions may include equipment listed for the atmosphere, which may be acceptable.

- See INTERNATIONAL MECHANICAL CODE Sec. 304.1
- See ANSI/ACCA Manual SPS 2010 Sec 1-6.
- See NFPA National Fuel Gas Code (2002) Sec. 8.1.6

- See “Proper Venting of Gas Fueled Appliances”, Chimney Safety Institute of America, Plainfield, IN, 2010
- See “Instruction Sheet IV, Identifying and Correcting Burner Problems”, Propane Council, Washington, DC, 2010.

Combustion equipment cannot be allowed to breathe halogen compounds, because acids will form in the flue and destroy it, allowing carbon monoxide and other combustion products to enter the occupied space.

4.9.1.7.2.4 No Openings D&C

There should be no ducts, grilles, pass-throughs, or other openings connecting such spaces to a NATATORIUM. Exceptions may include HVAC equipment which is rated for NATATORIUM atmosphere and which serves only that NATATORIUM shall be acceptable.

Note: Ducts which connect the NATATORIUM to the duct connections of air handlers should not be construed as connecting the air-handler space to the NATATORIUM.

- See INTERNATIONAL MECHANICAL CODE Sec. 304.1
- See ANSI/ACCA Manual SPS 2010 Sec 1-6.

4.9.1.7.2.5 Openings / Gaps D&C

Where building construction leaves any openings or gaps between floors and walls, or between walls and other walls, or between walls and ceilings, such gaps should be permanently sealed against air leakage.

- See ANSI/ACCA Manual SPS 2010 Sec 12-3.

4.9.1.7.3 Natatorium Access D&C

4.9.1.7.3.1 Floor Slope D&C

Where a door or doors must be installed in a wall between an EQUIPMENT ROOM and a NATATORIUM, the floor of the EQUIPMENT ROOM should slope back into the EQUIPMENT ROOM in such a way as to prevent any equipment-room spills from running under the door into the NATATORIUM. Exceptions may include:

- This may be met by a floor all of which is at least four inches below the level of the nearest part of the NATATORIUM floor.
- This may be met by a continuous dike not less than four inches high located entirely within the EQUIPMENT ROOM, which will prevent spills from reaching the NATATORIUM floor.

Note: Equipment-room floor drains may be required and all designs shall be compliant with ADA as they may be applicable.

Cleaning Supplies D&C

Even if POOL chemicals and cleaning supplies are not in the EQUIPMENT ROOM, there is a very good chance that other fluids may be, e.g. ethylene-glycol heating fluids, petroleum refrigeration oils, polyol-ester refrigeration oils, alkyl-benzene refrigeration oils, other lubricants, caustic or acidic coil cleaners, etc.

4.9.1.7.3.2 Automatic Closer

D&C

Such door or doors should be equipped with an automatic closer. The door, frame, and automatic closer shall be installed and maintained so as to ensure that the door closes completely and reliably without human assistance.

4.9.1.7.3.3 Automatic Lock

D&C

Such door or doors should be equipped with an automatic lock. Such lock shall require a key or combination to open from the NATATORIUM side. Such lock should be so designed and installed as to be opened by one hand from the inside of the room under all circumstances, without the use of a key or tool.

4.9.1.7.3.3.1 Restrict Access

D&C

Such doors should be equipped with permanent signage warning against unauthorized entry.

4.9.1.8 Other Equipment Room Guidance

D&C

4.9.1.8.1 Access Space

D&C

Where ventilation, air filtration, or space dehumidification, heating, or cooling for a NATATORIUM is by mechanical equipment located in an EQUIPMENT ROOM, adequate access space should be provided to allow for inspection and service.

- See NEC Art. 110-26 Minimum clearances.
- See INTERNATIONAL MECHANICAL CODE Sec. 304.1.
- See NFPA 54 National Fuel Gas Code Sec. 8.1.2

4.9.1.8.1.1 Size Requirements

D&C

The access spaces should be the greater of:

- Those required by OSHA, NEC, National Fuel Gas Code, or other official requirements; or
- The equipment manufacturer's recommendations.

4.9.1.8.2 Adequate Space

D&C

Where ventilation, air filtration, or space heating or cooling for a NATATORIUM is beside mechanical equipment located in an EQUIPMENT ROOM, adequate space for required straight lengths of duct shall be provided as the greater of those described in AMCA 201, SMACNA Duct Manual, ACCA Manual SPS Sec. 13, or the equipment manufacturer's recommendations.

- See ANSI/ACCA Manual SPS 2010 Sec 1-6.

- Air Movement and Control Association;
- Sheet Metal and Air Conditioning Contractors' National Association;
- Air Conditioning Contractors of America

4.9.1.8.3 Minimize Hazards

D&C

- See ANSI/ACCA Manual SPS 2010 Sec 1-6.
- See 29 CFR Part X 1926.1053(b)(9) (OSHA).

4.9.1.8.4 Refrigeration Equipment

D&C

Most refrigerants are heavier than air. When released from containment, most will evaporate rapidly, expanding greatly in the process. If a large enough amount is released, it could displace air to above head-height. For this reason mechanical CODES usually require refrigerant-release to the outdoors when the amount of refrigerant exceeds some fraction of the occupied volume.

4.9.2 Chemical Storage Spaces

D&C

POOL-chemical associated injuries have been routinely documented.^{268,269} For 2007-2008, 32 POOL chemical--associated health events that occurred in a public or residential setting were reported to CDC by Maryland and Michigan. These events resulted in 48 cases of illness or injury; 26 (81.3%) events could be attributed at least partially to chemical handling errors (e.g., mixing incompatible chemicals). ATSDR's Hazardous Substance Emergency Events Surveillance System received 92 reports of hazardous substance events that occurred at AQUATIC FACILITIES. More than half of these events (55 [59.8%]) involved injured persons; the most frequently reported primary contributing factor was human error. Estimates based on CPSC's National Electronic Injury Surveillance System (NEISS) data indicate that 4,574 (95% confidence interval [CI]: 2,703--6,446) emergency department (ED) visits attributable to POOL chemical--associated injuries occurred in 2008; the most frequent diagnosis was poisoning (1,784 ED visits [95% CI: 585--2,984²⁷⁰]). CDC has developed recommendations to reduce the risk of chemical-associated injuries at AQUATIC FACILITIES.²⁷¹ Designers and aquatics staff should read and consider findings and recommendations developed from investigations related to POOL chemical-related injuries. See "CDC Recommendations for Preventing POOL Chemical-Associated Injuries" at <http://www.cdc.gov/healthywater/swimming/POOLS/preventing-POOL-chemical-injuries.html>

The design for CHEMICAL STORAGE SPACE was included in the initial version of the MAHC Ventilation and Air Quality module AIR HANDLING SYSTEM design posted for public comment. It was, removed in the revised indoor AIR HANDLING SYSTEM design area of the

²⁶⁸ CDC. Acute illness and injury from swimming pool disinfectants and other chemicals --- United States, 2002--2008. MMWR Morb Mortal Wkly Rep. 2011;60(39):1343-1347.

²⁶⁹ CDC. Pool chemical--associated health events in public and residential settings---United States, 1983-2007. MMWR Morb Mortal Wkly Rpt. 2009;58(18):489-493.

²⁷⁰ Hlavsa MC, et al. Surveillance for waterborne disease outbreaks and other health events associated with recreational water use --- United States, 2007--2008. MMWR Surveill Summ 2011;60:1-37.

²⁷¹ CDC. Recommendations for Preventing Pool Chemical-Associated Injuries accessed at <http://www.cdc.gov/healthywater/swimming/pools/preventing-pool-chemical-injuries.html>

MAHC as part of revising the definition of an INDOOR AQUATIC FACILITY for which the AIR HANDLING SYSTEM does not include CHEMICAL STORAGE SPACE or other space outside the negative pressure zone around the AQUATIC VENUE. However, the building of an INDOOR AQUATIC FACILITY will still require considering the ventilation of CHEMICAL STORAGE SPACES using separate AIR HANDLING SYSTEMS.

Chemicals are typically stored in AQUATIC FACILITIES for the purpose of maintenance and water treatment. They can create ventilation hazards for PATRONS and staff.

INTERNATIONAL MECHANICAL CODE and International Fire Code provide very specific guidance on the construction and AIR HANDLING SYSTEM design of these areas. Often AQUATIC FACILITIES store chemicals in the pump room, but the operational STORAGE of these chemicals should be limited to what is necessary for immediate use. Back up supplies should be appropriately stored and maintained in a separate area designed according to the above STANDARDS.

Other key areas to consider for proper chemical STORAGE would include:

- Follow local building CODES and/or American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) STANDARDS or STANDARDS such as NFPA 5000: Building Construction and Safety Code requirements, or IBC Section 307.
- Separate the AIR HANDLING SYSTEMS for the CHEMICAL STORAGE SPACE and pump room from the rest of the building.
- Separate the AIR HANDLING SYSTEM for the AQUATIC VENUE area from the rest of the building.
- If an older AQUATIC FACILITY does not have separate AIR HANDLING SYSTEMS for the CHEMICAL STORAGE SPACE and pump room as well as the AQUATIC VENUE area, consider installing emergency heating, ventilating, and air conditioning (HVAC) cutoffs in these areas.
- Ensure that the CHEMICAL STORAGE SPACE, pump room, and AQUATIC VENUE area are well-ventilated.

Ventilate the CHEMICAL STORAGE SPACE, pump room, and AQUATIC VENUE area to the outside.

4.9.2.1	Outdoor / Indoor Storage	D&C
4.9.2.1.1	Stored Outdoors	D&C
4.9.2.1.2	Minimize Vapors	D&C
4.9.2.1.3	Dedicated Space	D&C
4.9.2.1.4	Safe Spaces	D&C

The number of required CHEMICAL STORAGE SPACES should be as necessary to allow safe STORAGE of the chemicals present.

4.9.2.1.5 Additional Space**D&C**

Where the listing, labeling, or MSDS of chemicals indicates incompatibility of STORAGE with other chemicals present, other CHEMICAL STORAGE SPACE(S) should be provided.

- See ANSI/ACCA Manual SPS 2010 Sec. 1-6.
- See ANSI/ACCA Manual SPS 2010 Sec. 12-3.
- See NFPA 704 “Hazard Identification System” for chemical rankings.
- See EPA Osver 90 008.1 Chemical Emergency Preparedness and Prevention Advisory SWIMMING POOL CHEMICALS: Chlorine.
- Calcium hypochlorite, sodium hypochlorite, muriatic acid, BCDMH, etc., have NFPA 704 health rankings of 3. IMC Sec. 502.8.4 and 502.9.2 apply.
- See Narnes, David, “Swimming Pool Chemical Safety”, http://www.ehow.com/way_5406877_swimming-pool-chemical-safety.html
- See CDC. Recommendations for Preventing Pool Chemical-Associated Injuries accessed at <http://www.cdc.gov/healthywater/swimming/pools/preventing-pool-chemical-injuries.html>

4.9.2.1.6 Eyewash**D&C**

It is the intent to allow re-fillable eyewash bottles and not require plumbed emergency eyewashes and showers unless required by the AHJ.

4.9.2.1.6.1 Outside**D&C**

The intent is to allow some flexibility since installation in the CHEMICAL STORAGE SPACE may be prone to failure due to corrosion. External eye wash stations should be close and easily found such as in a location outside the door that all staff must walk past. The MAHC will continue to look for data supporting a maximum distance from the door.

4.9.2.2 Construction**D&C**

As applicable, the STANDARDS of NFPA 400, the IFPC, and the IBC shall prevail. This STANDARD is not intended to provide relief from these other regulations, but to provide BEST PRACTICE where these regulations are not adopted or enforced. The more stringent STANDARD shall prevail as applicable.

4.9.2.2.1 Foreseeable Hazards**D&C****4.9.2.2.2 Protected****D&C****4.9.2.2.3 Floor****D&C**

The floor or DECK of the CHEMICAL STORAGE SPACE should be protected against substantial chemical damage by the application of a coating or sealant capable of resisting attack by the chemicals to be stored.

4.9.2.2.4 Minimize Fumes**D&C****4.9.2.2.5 Surfaces****D&C**

4.9.2.2.6 No Openings**D&C**

Other than a possible door, there should be no permanent or semi-permanent opening between a CHEMICAL STORAGE SPACE and any other INTERIOR SPACE of a building intended for occupation.

- See INTERNATIONAL MECHANICAL CODE Sec. 502.
- See ANSI/ACCA Manual SPS 2010 Sec. 1-6.
- See ANSI/ACCA Manual SPS 2010 Sec. 12-3.
- See NFPA 704 Hazard Identification System.
- See Sodium Hypochlorite MSDS, Health Hazard Data.
- See Calcium Hypochlorite MSDS, Health Hazard Data.
- See Hydrochloric Acid MSDS, Health Hazard Data.
- See Muriatic Acid MSDS, Health Hazard Data.

4.9.2.3 Exterior Chemical Storage Spaces**D&C**

As applicable, the STANDARDS of NFPA 400, the IFPC, and the IBC shall prevail. This STANDARD is not intended to provide relief from these other regulations, but to provide BEST PRACTICE where these regulations are not adopted or enforced. The more stringent STANDARD shall prevail as applicable.

4.9.2.3.1 Outdoor Equipment**D&C****4.9.2.3.2 Fencing****D&C**

Such part of an outdoor space as does not abut a wall of a building shall be completely enclosed by fencing that is at least 6 feet (1.8 m) high on all other sides.

4.9.2.3.3 Gate**D&C****4.9.2.4 Chemical Storage Space Doors****D&C**

As applicable, the STANDARDS of NFPA 400, the IFPC, and the IBC shall prevail. This STANDARD is not intended to provide relief from these other regulations, but to provide BEST PRACTICE where these regulations are not adopted or enforced. The more stringent STANDARD shall prevail as applicable.

4.9.2.4.1 Signage**D&C**

Signage should include information:

- Warning against unauthorized entry.
- Specifying the expected hazards, and
- Specifying the location of the associated MSDS forms.
- See NFPA 704 "Hazard Identification System".

4.9.2.4.2 Emergency Egress**D&C**

This usually takes the form of a kick-out panel in the door. When trapped, a person can sit down and kick out the panel, creating an opening usually about six inches narrower than the door and about 28 inches (0.71 m) high. Since these are used in most ENCLOSURES where a person can be trapped (e.g. walk-in freezers) the volume is high enough for additional expense to be minimal. Trapping could happen in several ways, but the most common is binding of the door to the jamb. Corrosion products can build up inside a metal door between the jamb and the wall, forcing the jamb away from the wall and toward the door. At some point the door will either fail to open or fail to close.

4.9.2.4.3 Interior Door

D&C

- Sodium Hypochlorite MSDS, Health Hazard Data, Spill Data.
- See Calcium Hypochlorite MSDS, Health Hazard Data, Spill Data.
- See Hydrochloric Acid MSDS, Health Hazard Data, Spill Data.
- See Muriatic Acid MSDS, Health Hazard Data, Spill Data.

4.9.2.4.4 Equipment Space

D&C

- See ANSI/ACCA Manual SPS 2010 Sec. 1-6.
- See ANSI/ACCA Manual SPS 2010 Sec. 12-3.
- See NEC Art. 110.11 “Deteriorating Agents”.
- See NEMA 250.
- See CSA C22.2.
- See UL 50.
- See UL 508.
- See NFPA National Fuel Gas Code (2002) Sec. 8.1.6
- See “Proper Venting of Gas Fueled Appliances”, Chimney Safety Institute of America, Plainfield, IN, 2010
- See “Instruction Sheet IV, Identifying and Correcting Burner Problems”, Propane Council, Washington, DC, 2010

4.9.2.4.4.1 Corrosive

D&C

Combustion equipment cannot be allowed to breathe halogen compounds, because acids will form in and destroy the flue. Air-handlers have strong negative air pressures inside them. This will draw in any CONTAMINANTS around the cabinet and distribute throughout the ducted system.

4.9.2.4.5 Interior Opening

D&C

4.9.2.4.5.1 Corrosion- Resistant

4.9.2.4.5.2 Automatic Locks

D&C

Most locks for employee-only doors in public buildings would qualify, since such locks must lock automatically from the outside, but cannot require a key or tool for exit. Examples of suitable lock types would include, but not be limited to, the locks on hotel-room doors, the lock on the door of a personnel-file STORAGE room, the lock on a janitor’s closet, etc.

- See ANSI/ACCA Manual SPS 2010 Sec. 1-6.
- See ANSI/ACCA Manual SPS 2010 Sec. 4-4.
- See ANSI/ACCA Manual SP 2010 Sec. 12-3.

4.9.2.5 Interior Chemical Storage Spaces

D&C

As applicable, the STANDARDS of NFPA 400, the IFPC, and the IBC shall prevail. This STANDARD is not intended to provide relief from these other regulations, but to provide BEST PRACTICE where these regulations are not adopted or enforced. The more stringent STANDARD shall prevail as applicable.

4.9.2.5.1 No Air Movement

D&C

- See ANSI/ACCA Manual SPS 2010 Sec. 4-4.

4.9.2.5.2 Electrical Conduit System

D&C

An interior CHEMICAL STORAGE SPACE that shares any building surface (wall, floor, ceiling, door, etc.) with any other INTERIOR SPACE or that shares an electrical-conduit system with any other space should be equipped with a ventilation system that maintains the air pressure in the CHEMICAL STORAGE SPACE below that of any other INTERIOR SPACE by 0.05 to 0.15 inches (1.3 to 3.8 mm) of water pressure, or by such greater pressure difference as should be necessary to ensure that all air movement through building surfaces or conduits should be toward the CHEMICAL STORAGE SPACE.

Note 1: This can usually be accomplished by maintaining the air pressure in the CHEMICAL STORAGE SPACE at least 0.05 I.W.C. to 0.15 I.W.C. below that of any adjoining SPACE and below that of any space connected to the CHEMICAL STORAGE SPACE by an electrical conduit system. Larger pressure differences may be needed in special cases.

Note 2: Where

- all conduits passing through the CHEMICAL STORAGE SPACE use only threaded joints within the CHEMICAL STORAGE SPACE, and
- all conduits terminating in the CHEMICAL STORAGE SPACE
 - are effectively sealed, and
 - use only threaded joints within the CHEMICAL STORAGE SPACE, the specified air-pressure difference need not include the air pressures of INTERIOR SPACES which do not share a building surface with the CHEMICAL STORAGE SPACE.

4.9.2.5.2.2 Pressure Difference

D&C

This pressure difference should be maintained by a continuously operated exhaust system used for no other purpose than to remove air from that one CHEMICAL-STORAGE SPACE.

4.9.2.5.2.3 Separate Exhaust System

D&C

4.9.2.5.2.3.1 Airflow Rate

D&C

4.9.2.5.2.4 Alarm D&C

4.9.2.5.2.4.1 Minimum Output D&C

4.9.2.5.2.4.2 Manual Reset D&C

- See ANSI/ACCA Manual SPS 2010 Sec. 1-6.
- See ANSI/ACCA Manual SPS 2010 Sec. 4-4.
- Differential pressure was extrapolated from *ASHRAE Applications Handbook*, Sec. 4.6 “*Natatoriums – Ventilation Requirements*”.
- See INTERNATIONAL MECHANICAL CODE, Sec 502.1.
- See ANSI/ACCA Manual SPS 2010 Sec. 1-6.
- See ANSI/ACCA Manual SPS 2010 Sec. 4-4.
- See ANSI/ACCA Manual SPS 2010 Sec. 12-3.
- See Sodium Hypochlorite MSDS, Health Hazard Data.
- See Calcium Hypochlorite MSDS, Health Hazard Data.
- See Hydrochloric Acid MSDS, Health Hazard Data.
- See Muriatic Acid MSDS, Health Hazard Data.
- See ANSI/ACCA Manual SPS 2010 Sec. 1-6.
- See ANSI/ACCA Manual SPS 2010 Sec. 4-4.

4.9.2.6 Air Ducts in Interior Chemical Storage Spaces D&C

4.9.2.6.1 No Air Movement D&C

- See INTERNATIONAL MECHANICAL CODE, Sec 502.1.
- See ANSI/ACCA Manual SPS 2010 Sec. 1-6.
- See ANSI/ACCA Manual SPS 2010 Sec. 4-4.

Ducts shouldn't be shared between spaces. Should the blower stop or fail there would be cross-contamination.

4.9.2.7 Pipes and Tubes in Interior Chemical Storage Spaces D&C

4.9.2.8 Combustion Equipment in Interior Chemical Storage Spaces D&C

4.9.2.8.1 Installed D&C

- See NFPA National Fuel Gas Code (2002) Sec. 8.1.6
- See “Proper Venting of Gas Fueled Appliances”, Chimney Safety Institute of America, Plainfield, IN, 2010
- See “Instruction Sheet IV, Identifying and Correcting Burner Problems”, Propane Council, Washington, DC, 2010.

4.9.2.9 Electrical Equipment in Chemical Storage Spaces D&C

4.9.2.10 Ozone Rooms D&C

4.9.2.11 Gaseous Chlorination Space D&C

Many current jurisdictions closely regulate the use of gas CHLORINE from a disaster preparation and response standpoint. This can make CHLORINE gas use prohibitive from a regulatory standpoint to the point that its use is difficult to justify.

4.9.2.12 Windows in Chemical Storage Spaces D&C

4.9.2.12.1 Not Required D&C

These windows are sometimes built into the door, although not always. (There are fire-rated doors with windows.) Such windows may serve several purposes.

4.9.2.12.2 Requirements D&C

Such windows are usually installed for free lighting, although there can be drawbacks. Some chemicals may react on exposure to sunlight.

4.9.2.13 Sealing and Blocking Materials D&C

4.10 Hygiene Facilities

4.10.1 General

Language similar to this section is found in most state CODES.

4.10.1.2 Hygiene Facilities HYG

During 2007–2008, 58 (82.9%) of 70 treated recreational water–associated outbreaks of diarrheal illness were caused by *Cryptosporidium*²⁷². These cryptosporidiosis outbreaks tend to disproportionately affect children <5 years of age and can cause community-wide outbreaks²⁷³. Infectious *Cryptosporidium* OOCYSTS' extreme CHLORINE tolerance allows them to survive for 3.5–10.6 days when free CHLORINE levels are maintained at 1–3 mg/L²⁷⁴. The OOCYSTS small size (4.5 µm x 5.5 µm) also allows them to bypass typical sand and cartridge filters²⁷⁵. While secondary or supplemental DISINFECTION can inactivate the OOCYSTS, these ultraviolet and ozone treatment systems are circulation dependent^{276,277,278,279,280}.

²⁷² Hlavsa *et al.* Surveillance for waterborne disease outbreaks and other health events associated with recreational water use and other aquatic facility–associated health events — United States, 2007–2008. MMWR Surv Summ. 2011;60(SS-12):1–37.

²⁷³ CDC. Communitywide cryptosporidiosis outbreak--Utah, 2007. MMWR Morb Mortal Wkly Rep. 2008;57(36):989–93.

²⁷⁴ Shields *et al.* Inactivation of *Cryptosporidium parvum* under chlorinated recreational water conditions. J Water Health 2008;6(4):513–20.

²⁷⁵ Smith H. Diagnostics. In: Fayer R, Xiao L, eds. *Cryptosporidium* and cryptosporidiosis. 2nd ed. Boca Raton, Florida: CRC Press, 2008:173–207.

²⁷⁶ Betancourt WQ, Rose JB. Drinking water treatment processes for removal of *Cryptosporidium* and *Giardia*. Vet Parasitol. 2004;126(1-2):219-34.

Thus, changing BATHER behavior in the following ways are needed to help prevent cryptosporidiosis outbreaks:

- Enforcement of policies that exclude swimmers with diarrhea,
- Swimmer education about hygienic swimming behaviors (e.g., taking a CLEANSING SHOWER before entering the water, not swallowing the water), and
- Using secondary or supplemental DISINFECTION.

Chloramines

HYG

During January–March 2007, >660 BATHERS and aquatic staff at a waterpark experienced respiratory symptoms and eye irritation caused by chloramines.²⁸¹ Chloramines form when free CHLORINE oxidizes nitrogenous compounds (e.g., sweat, urine, and personal care products) that wash off BATHERS' bodies. Chloramines can volatilize into the air where it can accumulate in air of indoor AQUATIC VENUES. One (17%) in five American adults reports having ever urinated in a POOL²⁸², and elite athletes can sweat >700 ml/h²⁸³. Rinsing off in the shower for 60 seconds and wearing bathing caps significantly decreases the amount of total organic carbon and total nitrogen²⁸⁴. Studies also suggest that ultraviolet treatment can reduce chloramine levels in the water^{285,286}.

Accumulation of chloramines in the air at indoor treated recreational WATER VENUES can be reduced with the following practices:

- Policies that require showering before entering the water,
- Swimmer education about hygienic swimming behaviors (e.g., taking a RINSE SHOWER and using the toilet before entering the water, not urinating in the POOL, and wearing bathing caps), and
- Using ultraviolet water treatment and improving ventilation.

²⁷⁷ Craik SA *et al.* Inactivation of *Cryptosporidium parvum* oocysts using medium- and low-pressure ultraviolet radiation. *Water Res.* 2001;35(6):1387-98.

²⁷⁸ Rochelle PA *et al.* The response of *Cryptosporidium parvum* to UV light. *Trends Parasitol.* 2005;21(2):81-7.

²⁷⁹ Corona-Vasquez B *et al.* Inactivation of *Cryptosporidium parvum* oocysts with ozone and free chlorine. *Water Res.* 2002;36(16):4053-63.

²⁸⁰ Korich DG *et al.* Effects of ozone, chlorine dioxide, chlorine, and monochloramine on *Cryptosporidium parvum* oocyst viability. *Appl Environ Microbiol.* 1990;56(5):1423-8.

²⁸¹ CDC. Respiratory and ocular symptoms among employees of a hotel indoor waterpark resort — Ohio, 2007. *MMWR* 2009; 58(4):81-85.

²⁸² Wiant C. A snapshot of swimmer hygiene behavior. *Int J Aquat Res Ed.* 2011;5(3):244-245.

²⁸³ Cox *et al.* Body mass changes and voluntary fluid intakes of elite level water polo players and swimmers. *J Sci Med Sport.* 5,3 (2002): 183-193.

²⁸⁴ Keuten MGA *et al.* Definition and quantification of initial anthropogenic pollutant release in swimming pools. *Water Res.* 2012;46:3682-3692.

²⁸⁵ Cassan D *et al.* Effects of medium-pressure UV lamps radiation on water quality in a chlorinated indoor swimming pool. *Chemosphere* 2006;62(9):1507-13.

²⁸⁶ Li J, Blatchley ER, 3rd. UV photodegradation of inorganic chloramines. *Environ Sci Technol* 2009;43(1):60-5.

4.10.1.5 Bather Load**HYG**

The minimum number of RINSE SHOWERS and CLEANSING SHOWERS should have fixture counts correlated directly to the BATHER LOAD. Any fixture counts above this should be accordance with the AHJ's requirements.

4.10.2 Location**4.10.2.1 Distance****HYG**

The intent of this code item is to discourage PATRONS from drinking POOL water and encourage them to keep themselves hydrated. The intent is also to encourage PATRONS to use the HYGIENE FACILITIES rather than urinating in the POOL or changing diapers at the side of the AQUATIC VENUE or on AQUATIC VENUE furniture. Restrooms need to be easily accessible & available to PATRONS of AQUATIC VENUES so that they will use restrooms rather than urinating or defecating in the VENUE water, which is common. Unlike other recreational facilities, people feel that it is more acceptable to "pee in the POOL" than to not use sanitary facilities for these bodily functions and other locations. This may not be possible in large waterparks, however, they can possibly be located within 300 feet (61m) from the AQUATIC VENUE. The distance needed for parents to walk or carry DIAPER-AGED CHILDREN should be shorter (200ft or 61 m) to ensure use. When possible, it is preferable to have a bathroom on the same floor as the AQUATIC VENUE; however, it is not required at this time in the MAHC.

Drinking water should be available so that PATRONS, especially young children, are less likely to drink POOL water and to ensure that PATRONS are kept well-hydrated.

These distances are found in multiple state or local CODES including Wisconsin, Oregon, Florida, and New York.

4.10.2.2. Diaper-Aged Children**HYG**

There are specific types of AQUATIC VENUES that pose an INCREASED RISK of fecal contamination of the water and transmission to BATHERS such as WADING POOLS, WATER ACTIVITY POOLS, INTERACTIVE WATER PLAY VENUES, or other AQUATIC VENUES designed primarily for DIAPER-AGED CHILDREN under five years of age. For these AQUATIC VENUES, diaper changing areas should be located directly adjacent to the kiddie areas to promote use.

It is especially important that HYGIENE FACILITIES be available to these increased risk groups. Children less than five years of age have the highest incidence of diarrheal illness and are more likely to be a source for spreading recreational water illnesses.

4.10.3 Design and Construction**HYG**

Language similar to this section is found in most state CODES.

4.10.3.1 Floors**HYG**

“Slip resistant” is usually considered to mean having a static coefficient of friction of 0.6 or better for both wet and dry conditions. Currently, this ASTM STANDARD C1028 is under revision.

4.10.3.2 Floor Base**HYG**

The purpose of coving is to prevent water splashing on the wall when mopping. Six inches, a common height, was taken from building CODE.

- For further information, also see the FDA Model Food Code for Kitchens.

4.10.3.3 Floor Drains**HYG****4.10.3.3.1 Opening Grill Covers****HYG**

Holes in floor drain cover openings need to be sized to prevent small children’s toes from becoming entrapped when walking over them.

4.10.3.3.2 Sloped to Drain**HYG**

Floors not sloped to drain have been shown to allow bacterial growth on indoor and outdoor AQUATIC VENUE POOL DECKS.

4.10.3.5 Hose Bibb**HYG**

The purpose of these hose bibs is to permit adequate cleaning of shower and toilet facilities and to permit cleaning of any spills occurring in the HYGIENE FACILITY. See also MAHC 6.5 for further rationale.

4.10.4 Plumbing Fixture Requirements**HYG**

Language similar to this section is found in most state CODES.

4.10.4.1.1 Protected**HYG**

It is fundamental that there be no cross connections between safe (potable) and unsafe (non-potable) water supplies. All hose bibbs should be equipped with a vacuum breaker to prevent back siphonage. This cross-connection protection can also be achieved at lavatories and laundry tub washing facilities through an air gap. As a general rule, the INLET pipe is terminated at a distance about four times the diameter of the pipe and not less than 4 inches above the maximum overflow level of the fixture rim.

4.10.4.1.3 Toilet Counts**HYG**

Facilities in jurisdictions with requirements governing the number of sanitary facilities shall follow those requirements. AQUATIC FACILITIES with an average PATRON load of over 100 persons should follow the International Plumbing Code (IPC). Facilities with average PATRON loads of less than 100 persons should follow either the IPC or Uniform Plumbing Code (UPC). The IPC may require significantly more toilet facilities for women than for men.

Gender Potty Parity**HYG**

Previous issues of the nation's model consensus code mandated an equal amount of toilet fixtures for both men and women. Newer versions of the code will likely provide recommendations that increase the minimum required facilities for women.

Potty Parity discussion from Reasons to Adopt the 2000 IPC, developed by the International Conference of Building Officials (ICBO) as an informational aid to code officials and the public.

The IPC requires far less HYGIENE FIXTURES for various types of occupancies than the UPC. This is contrary to the "potty parity" movement which demands more fixtures for women's toilet rooms to avoid the long waiting lines. The UPC also provides more water closets and urinals in most men's toilet rooms than the IPC and assures adequate water closets by limiting the number that can be deleted by installing additional urinals.

The authors of the ICBO have suggested that the provisions of the UPC reflect what the "potty parity movement" called for. The IPC is based upon research. The provisions of the IPC do address the issue of "potty parity" and reflect studies by Dr. Sandra Rawls at the University of Virginia, the Stevens Institute of Technology, the National Restaurant Association and the ASPE Research Foundation. The issue of "potty parity" is mostly an issue in assembly buildings with large OCCUPANT LOADS, especially where there is a period of high demand such as at intermission at a theater or at halftime at a football stadium. The "potty parity" is not an issue for occupancies where there is no instantaneous demand on the fixture usage. IPC Table 403.1 reflects requirements for twice as many fixtures in the ladies' room compared to the men's room, when the type of occupancy demands such a count. In occupancies where the factors do not demand such an increase, the code does not require it. It should also be pointed out that part of this issue arises because of some CODES requiring both water closets and urinals within the men's restroom. Therefore, the numbers for men were somewhat higher. The IPC does not have a mandatory requirement for urinals. It will generally require the same number of fixtures in the men's and women's restrooms. However, when two or more water closets are required, the IPC will permit up to 67 percent of the fixtures to be replaced by urinals. For additional supporting information, see the booklet IPC: A Guide for Use and Adoption:

<http://www.codereviewinc.com/download/plumbing%20code%20use%20ICC.pdf>

Some differences between the IPC and UPC CODES on this issue are as follows:

IPC**HYG**

- Utilizes a fixed fixture to OCCUPANT LOAD ratio.
- Does not mandate urinals for men.
- Allows Up to 67% of the requirement for water closets to be substituted for urinals.
- Establishes a separate fixture calculation factor for men and women. In some cases twice as many fixtures are required for women compared to men.
- No arbitrary parity requirement.

UPC**HYG**

- Utilizes a variable fixture-to-OCCUPANT LOAD ratio.
- Requires urinals to be installed based on a fixture-to-OCCUPANT LOAD ratio. Does not allow for one to one substitutions. For each urinal added over what is required, you may have one to one substitutions up to 2/3 of what is required.
- Requires the total number of WC's for women to be equal to the total number of WC's and urinals for men.

4.10.4.2 Cleansing Showers**HYG**

The purpose of CLEANSING SHOWERS described in this section is to remove dead skin, sweat, nitrogenous waste, and perianal fecal material before BATHERS enter the POOL. This is best done through nude showering using warm water and soap.

An average of 0.14 grams of fecal material can be found on a person's peri-anal surface (the amount of feces for children ranges from 0.01-10 grams and for adults 0.0001 to 0.1 g²⁸⁷. Therefore, fecal contamination of the perianal area is common. This contamination may include the CHLORINE-tolerant parasite *Cryptosporidium*²⁸⁸ which is not inactivated by routine disinfectant levels required in AQUATIC VENUES. Since the effectiveness of most halogen-based disinfectants is reduced by the presence of organic material, the purpose of CLEANSING SHOWERS is to reduce the inorganic, organic, and fecal load introduced into POOLS.

4.10.4.2.1 Count**HYG**

The ratio of 1:40 is currently required in the following states: Washington, Colorado, Oregon, Rhode ISLAND, Wyoming, New Hampshire, Louisiana, Massachusetts, and Nevada. Based upon current state CODES and data, this requirement should not place an unnecessary burden on AQUATIC FACILITIES and offering more showers per BATHER will encourage BATHERS to shower prior to entering water. Further research on this topic is recommended and can be addressed in future versions of the MAHC.

4.10.4.2.5 Location**HYG**

The placement of the showers is intended to encourage BATHERS to see and use the showers before they enter the water.

4.10.4.2.8 Exemption**HYG**

“Residential settings” includes condos, apartments, and homeowners associations. The intent is for BATHERS to use their rooms/homes for a CLEANSING SHOWER; however, one RINSE SHOWER on the DECK is required at these AQUATIC FACILITIES encouraging BATHERS to shower prior to entering water if a BATHER had not already done so.

4.10.4.2.6 Enclosed**HYG**

²⁸⁷ Gerba CP. Assessment of enteric pathogen shedding by bathers during recreational activity and its impact on water quality. *Quant Micro*. 2000;2:55-68.

²⁸⁸ Yoder JS and Beach MJ. *Cryptosporidium* surveillance and risk factors in the United States. *Experimental Parasitology*. 2010;124(1):31-39.

Entryways to CLEANSING SHOWER compartments shall be enclosed to provide privacy. Individual shower stall curtains and doors are not required. Providing privacy for CLEANSING SHOWERS promotes BATHER cleansing prior to entering AQUATIC VENUES.

4.10.4.3 Rinse Showers

HYG

The purpose of the RINSE SHOWERS is to remove inorganic material such as sand or dirt that can bind with CHLORINE and reduce the amount for other pathogen inactivation. Rinsing with water also removes BATHER'S CONTAMINANTS such as sweat, hygiene products, deodorant, hair spray, etc. Rinsing off in the shower for 60 seconds and wearing bathing caps significantly decreases the amount of total organic carbon and total nitrogen²⁸⁹.

A RINSING SHOWER can be taken on the DECK in open showers by the AQUATIC VENUE using ambient temperature water so dirt and other CONTAMINANTS are rinsed off before entering the water.

4.10.4.3.3 Floor Sloped

HYG

Floors of RINSE SHOWERS shall be sloped to drain waste water away from the AQUATIC VENUE and any landscaping areas if present. The intent is to prevent landscaping materials from being tracked back or washed into the AQUATIC VENUE area.

4.10.4.3.4 Large Aquatic Facilities

HYG

The intent is to encourage BATHERS to see and use the RINSE SHOWERS before they enter the water.

4.10.4.3.5 Beach Entry

HYG

The intent of having at least four showerheads every 50 feet at a beach entry allows multiple people to rinse off at the same time. Showerheads could be provided as wall units, pedestals (one pedestal could have four showerheads or two pedestals could have two showerheads each), allowing AQUATIC FACILITY owners to have versatility in design.

4.10.4.3.6 Lazy River

HYG

BATHERS enter LAZY RIVERS only in designated areas; therefore locating RINSE SHOWERS near these entrances facilitates rinsing before entering the LAZY RIVER.

4.10.4.3.7 Waterslide

HYG

BATHERS congregate into queue lines for access to waterslides. Providing a RINSE SHOWER on the DECK of a queue line encourages use prior to entering the water.

4.10.4.4 All Showers

HYG

4.10.4.4.1 Exceptions

HYG

²⁸⁹ Keuten MGA et al. Definition and quantification of initial anthropogenic pollutant release in swimming pools. Water Res. 2012;46:3682-3692

The intent is to encourage use of showering prior to entering an AQUATIC VENUE. Large AQUATIC FACILITIES, based on their BATHER LOAD, would require a large number of CLEANSING SHOWERS which would put an economic burden on these facility types. The MAHC acknowledges CLEANSING SHOWERS are more expensive to install than RINSE SHOWERS, therefore as long as the required number of showers is met, AQUATIC FACILITIES can decide which type of shower is conducive for their PATRONS.

In addition, the 2012 International Swimming Pool and Spa Code (ISPSC) Section 609.3.1 allows flexibility on the ratio of CLEANSING to RINSE SHOWERS above 7500 square feet of water surface area.

4.10.4.5 Diaper-Changing Stations

HYG

The material in this section addresses diapering of infants and young children. These are the age groups most commonly involved in contamination of recreational water that can lead to outbreaks of illness associated with recreational water. Although some older persons must wear diapers the incontinence is not likely to be associated with a diarrheal illness so the risk of infection from adults is much less than that from children. Therefore, we do not believe that special regulations are needed for elderly BATHERS. Current DIAPER-CHANGING UNIT designs do not supply all the features needed for sanitary and efficient diaper changing and clean-up to minimize spreading pathogens further in the AQUATIC FACILITY.

The MAHC defines a DIAPER-CHANGING STATION to include the following:

- A DIAPER-CHANGING UNIT,
- An adjacent hand washing sink,
- Soap with dispenser,
- Trash receptacle, and
- Necessary cleaning materials for the DIAPER-CHANGING UNIT.

4.10.4.5.2 Hand Wash Station

HYG

HAND WASH STATIONS are required adjacent to DIAPER-CHANGING STATIONS to promote use after using the toilet/urinal or changing diapers. Facilities will have 1 year after adoption on this MAHC section to install a plumbed sink with soap and dispenser, hand drying device/or paper towels and dispenser, and trash receptacle.

4.10.4.5.3 Portable

HYG

If a permanently plumbed hand wash sink is not economically feasible to install, a portable HAND WASH STATION can be used as a substitute for one year. Portable HAND WASH STATIONS are used at temporary events and include a water and waste tank that requires frequent refilling and draining for continual use.

4.10.4.5.4 Conform

HYG

There appear to be two different configurations of DIAPER-CHANGING UNITS currently available and suitable for this setting. The first type, a fold-down commercial unit commonly mounted on the wall, is addressed by ASTM F2285-04 consumer

performance STANDARDS for commercial DIAPER-CHANGING STATIONS. The second type, a free-standing unit, is addressed by Caring for Our Children: National Performance Standards for Out-of-Home Child Care (<http://nrckids.org>).

A major difference between these two designs is that ASTM F2285-04 calls for restraining straps while CFOC prohibits the use of straps and relies on a 3 inch (8cm) lip to keep children from falling off. Both designs have inherent problems. The problems with straps are associated with cleaning and possible hanging hazard. The problem with a 3 inch (8cm) lip is that they are not available on fold-up units. The MAHC language does not discriminate between these two designs, but the unit used should conform to one of these two STANDARDS.

4.10.4.5.5 Unisex

HYG

Increasingly, many venues are providing family dressing areas and caregiver rooms to attend to family needs. This provision permits parents to attend to the needs of small children of the opposite sex.

4.10.4.5.6 Trash Can

HYG

Trash receptacles are needed to help maintain cleanliness around the DIAPER-CHANGING STATION for any disposable changing unit covers, diapers, sanitizing wipes, or disposable paper towels.

4.10.4.6 Non-Plumbing Fixture Requirements

HYG

4.10.4.6.4 Lockers

HYG

While some lockers are designed to sit directly on the floor, other lockers may need to be elevated. This prohibits water accumulation beneath the lockers. Such accumulation can lead to the growth of mold, mildew, and slime build up.

4.10.4.6.6 Dryers/Paper Towels

HYG

Hand drying devices or paper towel dispensers should be located adjacent to the hand washing sinks to facilitate use. To prevent overcrowding, they may be positioned to move users away from the sink and toward the exit. In childcare settings, the dispensers and devices are usually within arms reach of the sink.

4.10.5 Provision of Suits, Towels, and Shared Equipment

4.10.5.1 Adequate Space

HYG

Although providing reusable bathing suits is no longer common, many AQUATIC FACILITIES provide PATRONS with towels and other shared equipment. The purpose of this wording STANDARD is to ensure that these AQUATIC FACILITIES provide adequate equipment and space in their design and construction for laundering, sanitizing, and drying these items.

4.10.6 Foot Baths**HYG****4.10.6.1 Prohibited****HYG**

FOOT BATHS with standing water allow the buildup of organic material and bacterial and fungal growth and can lead to the spread of pathogens.

4.10.7 Sharps**HYG****4.10.7.1 Container****HYG**

This section was included to address AQUATIC VENUES that provide PATRONS with sharps, especially razors, so that safe disposal is assured. Approved sharps containers are rigid, leak-proof, puncture resistant boxes of various sizes made of hard red plastic. They have a lid that can be securely sealed to keep contents from falling out, and they are clearly marked with the bio-hazard symbol. OSHA regulations describe the design and use of sharps containers for a variety of settings.

Businesses are required by the Occupational Safety and Health Administration (OSHA) to deposit sharps into a sharps container that complies with OSHA regulations in order to protect employees. Once that container is full, it must be disposed of according to state and federal regulations.

4.11 Water Supply / Wastewater Disposal**4.11.1 Water Supply****D&C****4.11.1.1.1 Other Sources****D&C**

These water systems include community water systems, non-transient non-community water systems, or transient non-community water systems with some noted exceptions.

There are several lake and spring sources around the country that have been used for decades to supply water to AQUATIC FACILITIES. As long as the source water quality does not significantly change and can be treated by the AQUATIC FACILITY equipment to protect the health and SAFETY of PATRONS, it can be allowed.

4.11.1.1.2 Condensate / Reclaimed Water**D&C**

The steps necessary to make reclaimed water meet source water STANDARDS are beyond the scope of the MAHC. These steps are set by the state and federal agencies that set requirements for drinking water.

This would be up to the AHJ and local conditions. The MAHC Technical Committee felt that, especially considering recent affinities towards sustainability, reclaiming condensate would be acceptable as long as this water met the same STANDARDS as incoming domestic water (even if this required UV or other disinfectants, filters, etc.). A provision for deferring to the AHJ ruling based on locale was important to us as well. For instance, this may be more of a politically important issue in Arizona or Nevada than in

other areas of the country. Non-potable use for this water is in keeping with water as a limited resource.

4.11.1.2.1 Refill Pool

D&C

This requirement is for when AQUATIC FACILITIES choose to be open when backwashing (e.g., they can backflush one filter while still maintaining filtration through another system; operating without the RECIRCULATION SYSTEM running is prohibited). A facility may choose to regulate when their backwash cycles occur (such as at closing). Many fully automated backwash systems for HRS filters are programmed to backwash at night when the facility is closed and there are no other demands on the source water coming into the facility. Alternatively, QUALIFIED OPERATORS may choose for an all deep 50 meter POOL to just backwash one filter at a time and allow make-up water to reestablish rim flow before doing the next one, as opposed to doing all six or eight tanks sequentially.

4.11.2 Fill Spouts

4.11.2.1 Hazard

D&C

For example, a fill spout located under a diving board or next to a ladder or handrail is less likely to be a trip hazard or be a hazard to swimmers coming up from below.

4.11.3 Cross-Connection Control

4.11.3.1 Protected

D&C

An air gap can be provided through a fill spout at the side of an AQUATIC VENUE, through water supply piping over the edge of an open balance tank or surge tank, or over a fill stand pipe that is connected to the side of an AQUATIC VENUE.

Splash guards are simply a means to keep fill water from splashing onto adjacent floors and walls. Water cannot be siphoned into the potable water supply through a properly designed splash guard. A proper design often consists of a concentric pipe that is a larger diameter than the fill pipe and that is open to the atmosphere at the top and bottom.

Because of the potential for back pressure or back siphonage, any potable water piping connected directly to any AQUATIC VENUE piping must have an RPZ. Some permitting agencies or CODES may allow pressure vacuum breakers or atmospheric vacuum breakers on water supplies not connected to the POOL piping but supplying potable water to the AQUATIC VENUE through a submerged INLET in the AQUATIC VENUE.

The pressure vacuum breaker would be located upstream of the shut-off valve.

The atmospheric vacuum breaker would be located downstream of the shut-off valve.

The AHJ may allow an elimination of an air gap to control splashing or flow of AQUATIC VENUE wastewater outside the receiving sump onto the EQUIPMENT ROOM floor. This can

be accomplished by extending the AQUATIC VENUE wastewater pipe below the rim of the sump. This can be approved if the wastewater disposal pipe from the AQUATIC VENUE does not have a sealed connection to the sewer piping. This constitutes an air break.

An air break can be justified for the worst case scenario of a sewer backup at the AQUATIC VENUE wastewater sump. During a sewer backup, sewage cannot back pressure into AQUATIC VENUE piping through an air break. Further, if the sewage is above the AQUATIC VENUE waste pipe outlet when the AQUATIC VENUE is operating, the normal pressure of the POOL piping leaks AQUATIC VENUE water towards the sewer, preventing the AQUATIC VENUE piping from siphoning wastewater. If the AQUATIC VENUE is not operating, then there is no pressure or suction in the piping that could create a condition for siphoning sewage.

If the permitting agency does not allow an air break, they may allow an air gap with a splash guard.

4.11.4 Deck Drains and Rinse Showers

4.11.5 Sanitary Wastes

4.11.6 Pool Wastewater

4.11.6.2 Ground Surface

D&C

Filters work to reduce the level of pathogens in the AQUATIC VENUE water by retaining the pathogen in the filter. As a result, AQUATIC VENUE backwash water has been demonstrated to contain detectable pathogen levels (e.g., *Cryptosporidium* and *Giardia*).^{290,291} Therefore, filter backwash water should be considered waste water requiring appropriate disposal.

4.11.6.4 Prohibit

R&F

If local or state CODES prohibit disposal of backwash filter media (perlite, cellulose or diatomaceous earth) directly to sanitary sewer, a separation tank may be recommended. The separation tank is to be designed for the conditions of the specific facility filtration system. The separation tank should be designed to accommodate the volume of water and spent media recommended for at least a single backwash (media change), without overflowing. The separation tank may include separation screens or a settling pit to allow for the spent media to be removed and properly disposed of according to AHJ requirements.

²⁹⁰ Shields JM, et al. Prevalence of *Cryptosporidium* spp. and *Giardia intestinalis* in Atlanta metropolitan area swimming pools. *Emerg Inf Dis* 2008;14:948-950.

²⁹¹ Schets FM, et al. *Cryptosporidium* and *Giardia* in swimming pools in the Netherlands. *J Water Health*. 2004 Sep;2(3):191-200.

4.12 Special Venues

4.12.1 Spas

4.12.1.2 Maximum Water Depth D&C

SPAS are designed for sitting and the expectation is that it will not be over the average 11-year-old child's head. That depth is about 48 inches (1.2 m). The Technical Committee felt that 24 inches (0.6 m) is reasonable since it's half of the maximum depth previously stated (4 ft) and would allow for the vast majority of the population to sit comfortably with their head above water. The Technical Committee also consulted the ISPSC and their maximum depth of 28 inches is pulled from APSP which has been utilized by industry for some time. The Technical Committee recommends additional studies to determine if decreasing the SPA seating depth is necessary.

4.12.1.3 Handholds D&C

Even though a person is seated in a SPA, a sufficient number of positive handholds are needed to assist with standing up. Handholds at the edge of the POOL above the water line are visible and easily reachable.

4.12.1.5 Perimeter Deck D&C

This is to provide adequate area for life saving and rescue purposes. The AHJ may allow a smaller rescue area based on the assessment of a local emergency rescue agency.

SPAS elevated for transfer wall or other purposes need to be provided with an effective BARRIER so that the elevated wall is not used as a platform to access an adjacent AQUATIC VENUE. An effective BARRIER shall be one that does not allow BATHERS to walk on the elevated wall.

Small and/or narrow SPAS are examples where the AHJ may allow a relief from the 50% minimum DECK requirements. The rationale is that if a SPA is of a limited size or width then it can be entirely be guarded effectively from one side or one location.

4.12.1.5.4 Elevated Spas D&C

For example, if an elevated SPA is next to or within 4 feet (1.2 m) of another AQUATIC VENUE, a guard rail or post-and-rope system would be a couple of options as effective BARRIERS which would discourage PATRONS to use this elevated wall to jump into the other AQUATIC VENUE.

4.12.1.7 Temperature D&C

Temperature above 104°F is essentially inducing a fever in the BATHER'S body as internal temperature rises. It is also teratogenic to fetuses so that pregnant women, particularly in their first trimester should consult their physician before using. Further research is needed to understand the potential role of SPA use early in pregnancy and associated birth defects. See MAHC Annex 5.7.4.6.2 for further discussion

4.12.1.14 Timers**D&C**

The “Fifteen Minute Rule” – complies with most state CODES. The timer for the hydrotherapy pump is for the SAFETY of the BATHERS. Longer times can be hazardous to BATHERS and the therapy pump shutting off at least reminds the BATHER to get out and reset the timer.

4.12.1.15 Emergency Shutoff**D&C**

Emergency shutoffs should be located between 5 feet (1.5 m) and 50 feet (15.2 m) and within sight of the SPA structure.

4.12.2 Water Slides and Catch Pools**4.12.2.1 Design and Construction****D&C****4.12.2.1.1 Additional Provisions****D&C**

The designs of WATER SLIDES are governed by amusement ride regulations such as ASTM that have appropriate experience. However, the design of the CATCH POOL along with associated water quality and circulation is regulated by this STANDARD.

4.12.2.2 Flumes**D&C****4.12.2.3 Flume Exits****D&C****4.12.2.4 Exit into Catch Pools****D&C**

Present practices for safe entry into CATCH POOLS include:

- a water backup, and
- a deceleration distance.

4.12.2.5 Catch Pools**D&C****4.12.2.6 Decks****D&C****4.12.2.7 Means of Access****D&C****4.12.2.8 Slide Run-outs****D&C****4.12.2.9 Drop Slides****D&C**

DROP SLIDES are being highlighted because of one incident that resulted in a fatality in Massachusetts. WATER SLIDES, particularly those that drop BATHERS into the water (vs. being delivered to water entry point), from a height above the water require diligent MONITORING by staff at the top of the slide and the water entry point to ensure there is adequate SPACING between slider users so that people do not land on top of each other. Each slide user must have time to move out of the collision zone before another slide user is allowed down the slide. The incident cited resulted in the drowning of a slide user and a multi-day time for discovery of the victim because of the high turbidity of the water.

4.12.2.10	Pool Slides	D&C
4.12.2.11	Signage	D&C
4.12.3	Wave Pools	
4.12.3.1	General	D&C
4.12.3.2	Access	D&C
4.12.3.3	Safety	D&C
4.12.3.3.3	No Diving Signs	D&C
4.12.3.4	Water Quality	D&C
4.12.4	Therapy Pools	
4.12.5	Leisure Rivers	
4.12.5.1	General	D&C
4.12.5.2	Access and Egress	D&C
4.12.5.2.1	Means	D&C

The WAVE POOL will still have side wall ladders for egress purposes (and therefore partial trafficking) and the Technical Committee still felt that “No Diving” signage should still be required for all areas around the WAVE POOL regardless of water depth due to the freeboard.

Since there is moving water in a LAZY RIVER, less frequent means of ingress/egress are acceptable. The moving water propels people around a LAZY RIVER quickly and with less effort to the next means of egress.

LAZY RIVERS can be several hundred feet long. They are often constructed with side walls that make it difficult to exit the water. This distance will make it so that a BATHER will never be more than 75 feet (22.9 m) from an exit. The distance to the nearest exit for a large regular POOL can be as much as 50 feet (15.2 m). This distance can be farther for a LAZY RIVER because of the current. If water is flowing at 1 – 4 feet/second around the river, then a person floating around a river will never be more than 2.5 minutes from a means of egress.

LAZY RIVERS are of necessity closed (or mostly closed) loops. The wall for the inside of a LAZY RIVER loop is an ISLAND which may be designed for people but is most often not. Therefore, a PERIMETER DECK is only needed for the outside of the river loop, or only on one side of the river.

4.12.5.2.4 Bridges**D&C**

Seven feet (2.13 m) minimum clearance overhead is required since it is consistent with requirements of building code minimum ceiling clearances.

Most LAZY RIVERS are closer to 3.5 feet deep making the clearance 7.5 feet if you adhere to the 4 foot clear requirement above the water surface. The MAHC Technical Committee chose 7 feet because it's the typical building code minimum height requirement for ceilings whereas the 6'-8 inches min clearance is usually only applicable to doorways.

4.12.5.3 Water Quality**D&C****4.12.5.4 Safety****D&C****4.12.6 Moveable Floors****4.12.6.1 General****D&C****4.12.6.2 Slip Resistance****D&C****4.12.6.3 Safety****D&C****4.12.6.3.1 Not Continuous****D&C**

Examples of adequate SAFETY precautions for entering the other area of the AQUATIC VENUE include but are not limited to the following:

- A moveable BULKHEAD, located at least at the water surface, to enclose the area of the MOVEABLE FLOOR;
- A highly visible floating line installed over the MOVEABLE FLOOR surface, two (2) feet in front of the end of the MOVEABLE FLOOR. A four (4) inch wide contrasting marking shall be provided at this leading edge.
- A railing system that shall be anchored into the MOVEABLE FLOOR.

4.12.6.3.2 Underside**D&C**

When the MOVEABLE FLOOR is not continuous over the entire surface area of the POOL, access to the underside of the MOVEABLE FLOOR shall be denied access when it's not flush with the POOL floor. Examples of adequate measures to prevent access under the MOVEABLE FLOOR include but are not limited to the following:

- Position a BULKHEAD at the end of the MOVEABLE FLOOR;
- Have a trailing ramp that hinges to the MOVEABLE FLOOR and extends to the POOL floor.

4.12.6.4 Movement**D&C****4.12.6.4.1 Speed****D&C**

There are no U.S. regulations on MOVEABLE FLOORS. This velocity was obtained from European design STANDARDS.

- European Standard EN 13451-11:2004.

4.12.6.5 Water Depth and Markings

D&C

4.12.7 Bulkheads

4.12.7.3 Entrapment

D&C

All BULKHEAD parking positions should be designed such that QUALIFIED LIFEGUARDS can see under 100% of the BULKHEAD from their station on the POOL DECK.

4.12.7.6 Gap

D&C

BULKHEADS designed with greater gaps may result in BULKHEADS veering off its intended path.

4.12.7.7 Handhold

D&C

During FINA sanctioned events, full height touchpads will be on most BULKHEADS. But the majority of BULKHEADS in the U.S. allow for wide holes at the waterline for handholds and USS / NFSHSA / NCAA touchpads which are hung from these holes and are below the waterline. Touchpads aren't normally installed during normal operating hours. End wall concrete parapets that cantilever over the gutter that require full height FINA touchpads for those level of competitions do not negate the requirement for handholds (though behind) in these locations.

4.12.7.10 Width

D&C

Any BULKHEAD that is intended for foot traffic for use by officials shall be at least 1 meter (3'-3") wide which is the current minimum width provided by commercial manufacturers.

4.12.7.10.1 Starting Platforms

D&C

Any BULKHEAD that dictates starting platforms shall be installed shall be at least 3'-9" (1.14 m) wide in order to allow for sufficient trafficking space for officials and athletes behind the starting platforms.

4.12.8 Interactive Water Play Venues

4.12.8.3 Sloped

D&C

An example for an acceptable design solution would be a diverter valve installation.

4.12.8.10 Hazard**D&C**

While consistent with many state CODES, the MAHC Technical Committee has determined that this topic needs more research regarding water velocity and eye SAFETY²⁹².

4.12.8.12 Signage**D&C**

Since there is no standing water on INTERACTIVE WATER PLAY VENUES, depth markers and “No Diving” warning signs are not required.

This was included because it deviates from the regular marking and warning signage requirements for typical AQUATIC VENUES as stated in this code. Other signage requirements such as diaper changing reminders and “do not drink” would likely be appropriate.

4.12.9 Wading Pools**4.12.9.2 Barrier****D&C**

A more stringent requirement is stipulated for separating WADING POOLS from other bodies of water (compared with the SPACING between other AQUATIC VENUES) is due to the fact that the predominant users of WADING POOLS are small toddlers, most of whom cannot swim, and the inherent dangers posed by larger and deeper POOLS in close proximity.

4.12.9.2.2 Shallow Water**D&C**

Rationale of 24” (0.6 m) deep rule is that if adjacent water is not substantively deeper than the WADING POOL, there is no need to segregate them.

²⁹² Duma SM, et al. Eye injury risk from water stream impact: biomechanically based design parameters for water toy and park design. *Curr Eye Res.* 2012 Apr;37(4):279-85.

Model Aquatic Health Code

5.0 Operation and Maintenance

5.1 Plan Submittal

5.2 Materials

5.2 Inspections

5.2.1 Preoperational Inspections

5.2.2 Exemptions

5.2.3 Variances

5.2.3.1 Variance Authority

REG

The permit issuing official may waive, in writing, any of the requirements of this code, and include the variance as a condition of the permit to operate, when it reasonably appears that the public health and SAFETY will not be endangered by granting of such a variance and adequate alternative provisions have been made to protect the health and SAFETY of the BATHERS and the public. The burden of providing the data and proof that any alternative provision is at least as protective as the code requirement is entirely on the permit holder.

5.2.4 Variance Requests

5.2.4.3.1 Hearing

REG

5.3 Equipment Standards

5.4 Aquatic Venue Operations and Facility Maintenance

5.4.1 Closure and Reopening

5.4.1.1 Short Closures

FMO

5.4.1.1.1 Short Closures

FMO

It is important for the QUALIFIED OPERATOR to be aware that when closed for even short periods of time, the AQUATIC VENUE distribution system, including drinking fountains and other potable water sources, may become stagnated. It is important to adequately ensure that all AQUATIC FEATURES should be adequately flushed and disinfected prior to reopening.

Standing water, including closed AQUATIC VENUES, can be a source of mosquitoes if DISINFECTION is halted. Although mosquitoes can carry many diseases such as dengue fever, malaria, and encephalitis, one of the most common mosquito-borne infections in

the US is due to West Nile virus which can cause fever and encephalitis. One study demonstrated a link between abandoned residential swimming POOLS, increases in mosquitos, and West Nile virus infections²⁹³. Swimming POOLS should be disinfected to prevent them from becoming public nuisance issues as mosquito breeding areas or SAFETY concerns.

Additionally, closed POOLS can be a SAFETY concern, especially for small children. When the POOL is not drained or covered tightly to prevent entry, children may knowingly or accidentally enter the POOL and drown. Because of the slime that often builds on the wall of these abandoned POOLS, it may be impossible for those that enter the POOL to climb out. Abandoned POOLS may also have limited visibility so people falling in cannot be seen by other persons in the area. While fence BARRIERS or SAFETY covers can create a “safe condition” for the POOL, these methods will not prevent the potential mosquito problems mentioned above.

5.4.1.1.2 Safe Condition

FMO

The closing of an AQUATIC FACILITY for less than seven days is considered a temporary closure. A closure of more than seven days is considered a long term closure. Both types of closure require certain maintenance activities when closing or reopening to ensure a safe environment for PATRONS.

5.4.1.2 Long Closures

FMO

5.4.1.2.1 Drain / Cover

FMO

POOLS that use a cover should refer to ASTM F1346-91. For POOLS where covers are not used or are not practical, access should be restricted and routine check of fence integrity is advised.

ASTM F1346 – 91: Standard Performance Specification for Safety Covers and Labeling Requirements for All Covers for Swimming Pools, Spas and Hot Tubs establishes requirements for SAFETY covers for swimming POOLS, SPAS, hot tubs, and WADING POOLS. When correctly installed and used in accordance with the manufacturer's instructions, this specification is intended to reduce the risk of drowning by inhibiting the access of children under five years of age to the water.

For long term and seasonal closures, where no residual disinfectant is maintained in the pipes, further research is needed to understand the growth of biofilms during closure. More research is needed to develop protocols for removing biofilms in AQUATIC VENUES.

If the AQUATIC VENUE system becomes non-operational, such as during a power outage, the AQUATIC VENUE should be cleared of BATHERS. Prior to reopening, the QUALIFIED OPERATOR should confirm that all systems are operational as required by the MAHC. For example, recoating DE filters will be necessary and it should be confirmed that feed

²⁹³ Reisen WK, Takahashi RM, Carroll BD, Quiring R. Delinquent mortgages, neglected swimming pools, and West Nile virus, California. *Emerg Infect Dis.* 2008;14(11):1747-9.

pumps did not continue feeding chemicals during a RECIRCULATION SYSTEM shutdown that may lead to outgassing into the POOL when the system is re-started.

5.4.1.2.1 Reopening

FMO

The QUALIFIED OPERATOR should refer to previous inspection reports for more details on repairs or replacements needed, and any replacements or new items should be discussed with the regulatory authority to verify they comply with current code requirements. It is recommended that a model Reopening Checklist be developed in the future.

5.4.2 Preventive Maintenance Plan

FMO

A preventive maintenance plan is a necessary and important part of any AQUATIC FACILITY operation. The best maintenance plan is one that follows the manufacturer's and POOL designer/engineer's recommendations for all equipment. A POOL maintenance plan is similar in many ways to the purchase of a new vehicle. With the purchase of a new vehicle, a manufacturer's maintenance schedule is included. The schedule lists the maintenance items that should be followed such as rotating tires and performing major tune-ups.

Likewise, the swimming QUALIFIED OPERATOR should perform an inventory of all equipment used in the AQUATIC FACILITY operation. For each piece of equipment the QUALIFIED OPERATOR should develop a list and schedule of maintenance items. By following this maintenance schedule, the operator can help prevent costly repairs and breakdowns in the future. Replacing items before they breakdown may prevent system breakdowns that could lead to outbreaks or injuries. For example, a common breakdown leading to loss of DISINFECTION is a break in the tubing leading from feed pumps to the RECIRCULATION SYSTEM. Although inexpensive, lack of replacement has been implicated in outbreaks.

AQUATIC FACILITIES need increased sophistication in plan maintenance and MONITORING.

5.4.2.1 Written Plan

FMO

5.4.2.2 Facility Documentation

FMO

5.4.2.2.2 Equipment Inventory

FMO

This inventory should contain information such as:

- Equipment name
- Manufacture with contact information
- Local vendor/supplier & technical representative
- Model number
- Horsepower, GPM, & filter size
- Year of manufacture
- Original cost
- Warranty

- Operating Manual

Equipment may be cataloged by area:

- DECK
- Lifesaving
- HYGIENE FACILITY
- Filter System
- Concession Stand
- AQUATIC FEATURES

5.4.3 General Operations

5.5 Aquatic Venue Structure (Shell)

5.6 Indoor/Outdoor Environment

5.6.1 Lighting

5.6.1.1 Lighting Maintained

FMO

5.6.1.1.1 Light Levels

FMO

System components will deteriorate and eventually need to be replaced, but lamp performance will continue to change prior to complete lamp failure. Indoor overhead lights, outdoor pole mounted lights, and underwater lighting are the key POOL light sources. Building lighting must also be maintained to provide safe facility use, building and area security, and meet the aesthetic goals. Planned lighting maintenance includes group relamping, cleaning lamps, cleaning luminaires, and replacing defective components on a regular basis.

Lamp lumen depreciation is a characteristic of all lamps. Each lamp type has a different lamp life, thus impacting your maintenance schedule. As lamps fail or burn out, the local light levels are decreased and the lighting uniformity is also affected.

Luminaire surface deterioration and dirt accumulation may also occur and can reduce the light reaching the needed areas. During relamping and cleaning, inspect each luminaire for deterioration or damage. Repair or replace components and inspect and clean light fixtures and luminaires as needed to maintain required light levels. Consider regular group relamping combined with cleaning as part of an efficient and effective maintenance plan.

Basic steps for cleaning and relamping operations include the following:

1. Turn off electrical circuits and carefully removing lenses, diffusers, shields and/or lamps.
2. Dispose of replaced lamps and ballasts per state and federal guidelines.

3. Contact the U.S. EPA for more information.
4. Follow the light fixture and lamp manufacturer's recommendations for cleaning, relamping and maintaining each light in good condition.
5. Routinely monitor underwater lights for proper operation.

Windows and natural lighting need to be evaluated seasonally and throughout the operating day.

Light levels may also be altered by dirty windows. Ensure that windows are cleaned regularly to eliminate any buildup of material that would affect light transmission.

5.6.1.1.2 Main Drain Visible

FMO

The requirement for being able to see the main drain from POOLside is a SAFETY issue. If QUALIFIED LIFEGUARDS or QUALIFIED OPERATORS cannot see the main drain then they are unable to see a person on the bottom of the AQUATIC VENUE and unable to initiate rescue procedures. This is cause for immediate closure and rectification before re-opening. Please refer to the MAHC Section 6.6.4 for more information.

5.6.1.2 Glare

FMO

In addition to discomfort, annoyance interference, and eye fatigue, glare reduces the visibility of an object. Without clear vision, there are increased chances for accidents that can cause injuries or potential drowning. Glare can be from reflections as well as direct lighting problems.

5.6.1.2.1 Assessments

FMO

The qualified operator or LIFEGUARD SUPERVISOR may consider adjusting lifeguard positions to improve visibility.

5.6.2 Indoor Aquatic Facility Ventilation

Maintenance and Repair

FMO

Drains on air-handling equipment should be tested before the system is started.

It is important that the drain system be checked regularly to ensure that the condensate drain pan, drain connection, and piping are free from buildup or blockages. In cases where air handling equipment is intended for use with P-trap type drains, the P-trap must be kept filled manually if normal operation does not keep the P-trap filled. If not kept filled, sewer gases, and odors can enter the system.

5.6.2.8 Combined Chlorine Reduction

VEN

Water chemistry affects air quality:

- The amount of disinfectant in the water should always be at sufficient level to disinfect properly, but high residual levels in an indoor environment contribute to the development of DBPs. A higher ratio of CHLORINE to nitrogen content in the water results in the formation of TRICHLORAMINE. Lower levels of

CHLORINE/bromine in the POOL results in lower levels of DBPs in the presence of organic and inorganic CONTAMINANTS.

- High residual levels have been a requirement for outdoor AQUATIC VENUES that have sunlight exposure, but that requirement may not be necessary for INDOOR AQUATIC FACILITIES.
- Free CHLORINE levels could likely be maintained at a lower level due to the absence of dechlorination due to sunlight.
- Lower pH levels increase the effectiveness of CHLORINE and by maintaining pH less than 7.5, less CHLORINE is required to achieve effective DISINFECTION²⁹⁴.

The water quality will affect the air quality in INDOOR AQUATIC FACILITIES. Also BATHER practices will determine not only the water quality but also the air quality. Therefore, if air handling equipment is installed, INDOOR AQUATIC FACILITY operators should develop and implement a program to operate, monitor and maintain the equipment as designed to reduce combined CHLORINE compounds introduced into the building from the AQUATIC FEATURES in accordance with the INDOOR AQUATIC FACILITY AIR HANDLING SYSTEM design engineer's and/or the AIR HANDLING SYSTEM equipment manufacturer's recommendations.

5.6.3 Electrical

5.6.3.1 Electrical Repairs

FMO

5.6.3.1.1 Local Codes

FMO

National Electrical Code Article 225 provides installation requirements for outside branch circuits and feeders that run on (or between) structures or poles.

National Electrical Code Article 680 applies to the construction and installation of electrical wiring for and equipment in or adjacent to all swimming, wading, therapeutic, and decorative POOLS; fountains; hot tubs; SPAS; and hydromassage bathtubs, whether permanently installed or storable, and to metallic auxiliary equipment, such as pumps, filters, and similar equipment.

5.6.3.2 Electrical Receptacles

FMO

5.6.3.2.2 Repairs

FMO

NEC Article 680.22 "General Circuitry Pool Pump Motors" states that "all 15- and 20-amp, single-phase, 125-volt or 240-volt outlets supplying pool pump motors shall have GFCI protection."

29 C.F.R. 1910.304 "Wiring Design and Protection" applies to temporary wiring installations that are used during construction-like activities, including certain maintenance, remodeling, or repair activities, involving buildings, structures or equipment.

²⁹⁴ White GC. Handbook of Chlorination and Alternative Disinfectants 4th edition. John Wiley and Sons, Inc. Hoboken New Jersey 1999.

5.6.3.3 Ground-Fault Circuit Interrupter**FMO****5.6.3.3.1 Manufacturer's Recommendation****FMO**

GFCI testing should follow the manufacturer's recommendations. However, the minimum test procedure should include:

- Testing personnel must wear shoes during the entire test. Where exposed terminals may be present, or where conditions warrant, other personal protective equipment may be required.
- A suitable indicating test load should be connected to the circuit under test, and remain so for the duration of the test.
- Test personnel should press the TEST button on the GFCI device.
- The test load should then be observed to have ceased operation due to loss of electrical power.
- Test personnel should next press the RESET button on the GFCI device.
- The test load should then be observed to have resumed operation.
- Where any of the conditions specified in steps (b) through (g) fail, the GFCI circuit must then be inspected and tested by a QUALIFIED PERSON. Replace the GFCI device as necessary.

POOL chemicals, fertilizers, salt, oxidizing cleaning materials, and other CORROSIVE MATERIALS should not be stored in any INTERIOR SPACE containing electric light fixtures, panel boards, fuses, circuit breakers, disconnects, motors, motor overloads, bonding conductors, or similar devices.

- Exception (a): Otherwise approved CHEMICAL STORAGE AREAS having light fixtures which are approved for use in corrosive atmospheres, and which serve the CHEMICAL STORAGE AREA only, should be acceptable.
- Exception (b): Otherwise approved CHEMICAL STORAGE AREAS having a light switch or switches approved for use in corrosive atmospheres, and which serve the CHEMICAL STORAGE AREA only, should be acceptable.
- Exception (c): Otherwise approved CHEMICAL STORAGE AREA containing small motors and the associated controllers, such as those for exhaust-blowers and peristaltic pumps should be acceptable where such motor circuits are protected by GFCI.
- Exception (d): Otherwise approved CHEMICAL STORAGE AREA containing devices listed and labeled for use in interior POOL-CHEMICAL STORAGE AREAS should be acceptable.
- Exception (e): Otherwise approved CHEMICAL STORAGE AREAS containing devices listed and labeled for use in corrosive atmospheres should be acceptable where approved by the AHJ.

Flammable liquids and flammable gases should not be stored in any INTERIOR SPACE containing electric light fixtures, panel boards, fuses, circuit breakers, disconnects, motors, motor overloads, bonding conductors, or similar devices, unless such devices comply with Article 500 of the NEC, or with the relevant local CODES.

POOL chemicals, acids, and fertilizers, salt, oxidizing cleaning materials and other corrosive or oxidizing chemicals should not be stored in INTERIOR SPACES where electrical conduits enter or pass through the space.

- Exception (a) Otherwise approved chemical STORAGE AREAS into which conduits enter or pass through should be acceptable, where such conduits
 - are sealed where they enter and exit the STORAGE space, and
 - are listed as corrosion resistant, and
 - serve only approved loads in the STORAGE space itself.
- Exception (b) Otherwise approved CHEMICAL STORAGE AREAS containing conduits approved for use in corrosive atmospheres should be acceptable if approved by the AHJ.

Where an INTERIOR SPACE was previously approved for STORAGE of POOL chemicals, acids, fertilizers, salt, oxidizing cleaning materials, other corrosive or oxidizing chemicals, or flammable liquids or gases and will continue to be used for such STORAGE, any replacement electrical parts or devices should be of the same type as the original equipment, or should be listed and labeled for such use.

No new electrical devices or equipment should be installed in an interior STORAGE space used for STORAGE of POOL chemicals, acids, fertilizers, and salt, oxidizing cleaning materials, or flammable liquids or gases without re-inspection by the AHJ.

An interior STORAGE space used for storing POOL chemicals, fertilizers, salt, oxidizing cleaning materials, other corrosive or oxidizing chemicals, or pesticides must be kept in ISOLATION from other INTERIOR SPACES, except for entry, egress, material transport, or alarm testing. The period of each instance of entry, access, or alarm testing should not exceed 15 minutes. The sum of the periods of all instances of breach of ISOLATION should not exceed 1 hour in each 24-hour period. Where the ISOLATION of an interior STORAGE space containing such chemicals from other INTERIOR SPACES containing COMBUSTION DEVICES depends on an interior door, such door should be gasketed to prevent the passage of air, fumes, or vapors, and should be equipped with an automatic door closer and an alarm that will give notice if the door remains open for more than five minutes. Function of this alarm should be confirmed monthly as part of scheduled maintenance. Failures of door gasketing, or of the door closer, or of the alarm should be repaired immediately.

Where any unsealed openings exist between an interior STORAGE space used for POOL chemicals, acids, fertilizers, salt, or corrosive or oxidizing chemicals and any other INTERIOR SPACE containing electrical equipment, the air pressure in the CHEMICAL STORAGE SPACE should be maintained at a level low enough to insure that all air flow should be toward the CHEMICAL STORAGE SPACE. This pressure difference should be maintained by a continuously operating exhaust system used for no other purpose than to remove air from the chemical-STORAGE space. Function of this exhaust system should be monitored continuously by a pressure switch and alarm. Function of the pressure switch and alarm should be confirmed monthly as part of scheduled maintenance. In the

event of failure of the exhaust system or of the alarm, repairs should be done immediately.

In any space containing electrical equipment, ambient conditions such as temperature, humidity, and maximum concentrations of chemical fumes or vapors, or of flammable fumes or vapors should be continuously maintained to meet the operational requirements of installed electrically powered equipment. Labels or other marks indicating the circuits served by fuses, circuit breakers, and disconnect switches should be maintained in a condition readable by a person unfamiliar with the function of the circuits.

For spaces containing fuses, circuit breakers, electric motors, or motor-operated loads, the recommended minimum illumination capability should be maintained as part of the scheduled monthly maintenance. STORAGE should not interfere with the largest of the minimum working clearances specified by the NEC, the equipment manufacturer, CFR 1910, or by local CODES or regulations.

Re-lamping operations within 20 feet horizontally of the nearest inside edge of a POOL, SPA, FLUME, WATER SLIDE or other open AQUATIC FEATURE should be carried out in such a way as to minimize the likelihood of lamp breakage. New lamps should be kept in their packing until just before installation. Old lamps should be packed immediately upon removal into a suitable container to prevent breakage. New lamps should not be stored in an interior STORAGE space used for POOL chemicals, fertilizers, salt, or other corrosive or oxidizing chemicals. Neither new lamps nor old lamps should be stored in the NATATORIUM, shower room, locker room, or hallways.

Where visible or accessible, any required bonding jumpers should be visually inspected for damage, breaks, looseness, or corrosion quarterly as part of scheduled maintenance. Where any doubt exists concerning the condition of bonding jumpers, a QUALIFIED PERSON should inspect and, if necessary, test the effectiveness of such jumpers.

5.6.3.4 Grounding

FMO

The purpose and objective of NEC Article 250 - Grounding is to insure that the electrical system is safe against electric shock and fires by limiting the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and a GROUND-FAULT (line-to-case fault). The rules contained in Article 250 identify the installation methods that must be followed to insure a safe electrical installation.

National Electrical Code Article 680 applies to the construction and installation of electrical wiring for and equipment in or adjacent to all swimming, wading, therapeutic, and decorative POOLS; fountains; hot tubs; SPAS; and hydromassage bathtubs, whether permanently installed or storable, and to metallic auxiliary equipment, such as pumps, filters, and similar equipment.

5.6.3.5 Bonding **FMO**

5.6.3.6 Extension Cords **FMO**

5.6.3.6.3 Exception **FMO**

The intent is to prevent the extension cord from reaching the water.

5.6.3.6.6 Compliance **FMO**

- See CFR 1910.304 (b)(2) at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9881

5.6.3.7 Portable Electric Devices **FMO**

5.6.3.8 Communication Devices and Dispatch Systems **FMO**

National Electrical Code Article 800 covers multi-purpose and communication cable. Multi-purpose cable is the highest listing for a cable and can be used for communication, Class 2, Class 3, and power-limited fire protective cable. Communication cable can be used for Class 2 and Class 3 cable and also as a power-limited fire protective cable with restrictions.

5.6.4 Facility Heating

5.6.4.1 Facility Heating **FMO**

5.6.4.1.1 Maintenance and Repair **FMO**

There are a number of CODES which can be consulted. These include but are not limited to the National Fuel Gas Code, National Electrical Code, and certain building CODES.

5.6.4.1.2 Defects **FMO**

If inspection shows excessive fouling of air filters before the cleaning or replacement period has ended, that period should be reduced to prevent overloading of filters. Filters that become clogged with dirt, mold, or other CONTAMINANTS can become a source of increased operating costs and poor air circulation. In addition to the reduction of system effectiveness, which can result in costly repairs, air-borne CONTAMINANTS can be spread as a result of improper air handling.

5.6.4.1.3 Temperature **FMO**

The air temperature of an indoor AQUATIC VENUE should be controlled to the original specifications where possible. Where this is not possible, the air temperature of a NATATORIUM should be controlled so as to prevent unexpectedly high levels of evaporation and to prevent condensation of water onto surfaces not designed for condensation. Particular care should be taken to prevent the condensation of water inside indoor AQUATIC VENUE building surfaces such as walls and ceilings. Please note that this code only looks at the part of the facility where the water “vessel” is located and

not at other areas of buildings (the building code would cover). Particular attention needs to be given to the prevention of algae and mold growth on surfaces.

- 5.6.4.2 Water Heating** **FMO**
- 5.6.5 First Aid Room**
- 5.6.6 Emergency Exit**
- 5.6.7 Plumbing**

- 5.6.7.1 Water Supply** **FMO**

- 5.6.7.1.2 Availability** **FMO**

The potable water pressure should be maintained to enable the AQUATIC VENUE and all other water using fixtures to operate to design specifications.

- 5.6.7.2 Drinking Fountains** **FMO**

- 5.6.7.3 Waste Water** **FMO**

In some AQUATIC FACILITIES, backwash water may be recycled for other purposes instead of wasted in order to conserve water. This water must be treated in accordance with local code requirements prior to being re-used. Backwash water is likely to be routinely contaminated with pathogens so its use should be carefully considered and health issues planned for prior to re-use. It should not be re-used in AQUATIC VENUES, but may be used in landscaping or other non-potable water uses.

- 5.6.7.4 Water Replenishment** **R&F**

- 5.6.7.4.1 Volume** **R&F**

See MAHC Annex section 4.7.4 for more information.

A minimum of 4 gallons (15 L) of water per BATHER per day must be discharged from the POOL, but a volume of 8 gallons (30 L) per BATHER per day is recommended. Backwash water will count toward the total recommended volume of water to be discharged, but evaporated water will not count since inorganic CONTAMINANTS (e.g., salts and metals) and many organic CONTAMINANTS (e.g., sweat and urine) can simply be concentrated as water evaporates. Backwash water or other discharged water may not be returned to the POOL without treatment to reduce the total organic carbon concentration, DISINFECTION BY-PRODUCT levels, turbidity, and microbial concentrations less than the limits set for tap water by the USEPA.

5.6.8 Solid Waste**5.6.8.1 Storage Receptacles****FMO****5.6.8.2 Disposal****FMO****5.6.9 Decks****FMO****5.6.9.1 Food Preparation and Consumption****FMO****5.6.9.1.2 Eating & Drinking****FMO**

Eating and drinking in AQUATIC VENUE areas may expose BATHERS to CONTAMINANTS. Food particles that fall into the POOL not only contribute to contamination burden, but may also affect POOL DISINFECTION. Additionally, contamination can occur through ingestion. Alcohol increases urine output and therefore creates more chloramines and other DISINFECTION BY-PRODUCTS if BATHERS do not regularly get out of the POOL to urinate. Regular bathroom breaks should be considered to reduce urination in the AQUATIC VENUE that allows designated areas like “swim-up bars” that may increase POOL urination and create compliance issues with MAHC combined CHLORINE levels. However, at this time, the MAHC does not have data suggesting that AQUATIC VENUES containing “swim up bars” have any more issues with water quality compliance issues than those AQUATIC VENUES that do not. AQUATIC VENUES considering “swim-up” bars need to be aware that these areas may also increase the risk of drowning caused by excessive alcohol consumption and should include this thinking in lifeguard training and in-service training.

Currently the majority of states do not allow swim up bars; however, Ohio, Hawaii, Texas, and a few local jurisdictions do, mostly in resort areas. The MAHC defers to local jurisdictions to assess and determine potential risks.

Another topic to consider is nursing mothers and SAFETY and health risk to infants. While many mothers consider nursing in the POOL a pleasant experience for the baby there is a definite SAFETY risk from hypothermia and a health risk from potentially ingesting contaminated POOL water that may contain organisms such as *Cryptosporidium*. See CDC Healthy Swimming discussion at <http://www.cdc.gov/healthywater/swimming/pools/breastfeeding-in-pools.html>

5.6.9.2 Glass**FMO**

Glass is prohibited in the POOL DECK area to prevent injuries to PATRONS. Most BATHERS are bare foot, so stepping on glass can cause serious injuries. If a glass container breaks in the AQUATIC VENUE vicinity it could potentially fall into the water. Clear glass is virtually invisible in water and is difficult to remove. The only way to ensure all broken glass is removed from POOL water is to thoroughly drain and clean the POOL structure. Depending on the size, draining and cleaning an AQUATIC VENUE can cost thousands of dollars.

5.6.9.3 Deck Maintenance FMO

5.6.9.3.1 Free From Obstructions FMO

DECKS should always be kept clear of obstructions to preserve space that may be needed for rescue efforts. Obstructions also cause tripping hazards and can lead to falls and serious injuries. Attention must also be given to potential fall hazards from slippery DECK areas.

5.6.9.3.3 Vermin FMO

It is important to maintain these areas free from debris, vermin, and vermin harborage. Animals can carry diseases which could be transmitted through bites or contact with bodily fluids or feces.

5.6.9.3.4 Original Design FMO

Proper maintenance of surfaces will help prevent abrasions to BATHERS and biofilm growth.²⁹⁵

5.6.10 Aquatic Facility Maintenance

5.6.10.1 Diving Boards and Platforms

5.6.10.1.1 Slip-Resistant Finish FMO

This can be accomplished by ensuring that the coefficient of friction is greater than or equal to that specified in MAHC Section 4.8.1.4.

5.6.10.2 Steps and Guardrails

5.6.10.3 Starting Blocks

5.6.10.4 Water Slides

5.6.10.5 Fencing and Barriers

5.6.10.6 Aquatic Facility Cleaning FMO

In-POOL cleaning systems must be periodically inspected to make sure they retract and stay flush with the floor.

5.7 Recirculation and Water Treatment

5.7.1 Recirculation Systems and Equipment

5.7.1.1 General R&F

5.7.1.1.3 Gutter/ Skimmer Pools R&F

²⁹⁵ CDC. An outbreak of *Pseudomonas* folliculitis associated with a waterslide – Utah. MMWR Morb Mortal Wkly Rep. 1983;32(32):425-7.

The recommendation for gutter or SKIMMER POOLS with main drains to have the majority of the water (at least 80% of the recommended recirculation flow) be drawn through the perimeter overflow system and no greater than 20% through the main drain during normal operation is based on subsurface distribution of bacteria data that showed most POOLS had higher surface concentrations of bacteria.²⁹⁶ For the 65 POOLS examined, surface concentrations of bacteria were an average of 3.4 times greater at the surface. However, about 30% of the POOLS showed the opposite trend with higher subsurface concentrations, which is why some operational flexibility is provided with these values.

For reverse flow (upflow) POOLS, 100% of the recommended circulation flow should be through the perimeter overflow system, which is consistent with the German DIN STANDARDS.²⁹⁷ Efficient removal of surface water is critical for maintaining water quality because surface water contains the highest concentration of pollutants from body oils, sunscreens, as well as other chemicals or particles that are less dense than water. Bacteria appear to follow the same trend in most cases²⁹⁸. The distribution of CHLORINE-resistant pathogens like *Cryptosporidium* is not known at present.

The majority of the organic pollution and contamination is concentrated at or near the surface irrespective of the mixing effects of the circulation:

5.7.1.2 Combined Aquatic Venue Treatment R&F

5.7.1.3 Inlets R&F

During regular seasonal operation following initial adjustments, INLETS should be checked at least weekly so that the rate and direction of flow through each INLET has not been changed substantially from the original conditions that established a uniform distribution pattern and facilitated the maintenance of a uniform disinfectant residual throughout the entire facility without the existence of dead spots.

A tracer test (e.g., with a sodium chloride tracer injected on the suction side of the pump) should be conducted annually at startup and documented to quantitatively assess distribution pattern in the POOL. An amount of salt sufficient to increase the baseline conductivity by at least 20% should be added over a 1 minute period, and the conductivity or TDS should be measured at 1 minute intervals until the conductivity increases by 20% and/or stops changing for 10 consecutive readings after an initial increase. Samples may also be taken at the corners, center, and bottom of the POOL (via a sample pump with the POOL unoccupied) in small labeled containers for later measurement to increase the amount of information available to assist in interpreting the results. Increases greater than predicted by the amount of salt added to the POOL volume indicate poor mixing. Areas with conductivities lower than in the return stream at the time the sample was collected are likely to be areas with poor recirculation flows.

²⁹⁶ Dick EC, Shull IF, and Armstrong AS. Surface-Subsurface Distribution of Bacteria in Swimming Pools – Field Studies. Am. J. Pub. Health. 1960;50:5:689-695.

²⁹⁷ Pool Water Treatment Advisory Group (PWTAG). Swimming pool water: treatment and quality standards for pools and spas, 2nd Ed. 2009. Micropress Printers, Ltd. ISBN: 0951700766.

²⁹⁸ Dick EC, Shull IF, and Armstrong AS. Surface-subsurface distribution of bacteria in swimming pools – field studies. Am. J. Pub. Health. 1960;50:5:689-695.

Note: It is possible to do a tracer test, which is quantifiable in terms of salt concentration ratios and/or time required to reach equilibrium concentration near the filter.

5.7.1.4 Surface Skimming Devices R&F

5.7.1.5 Submerged Drains/Suction Outlet Covers or Gratings R&F

5.7.1.6 Piping R&F

Winterization may involve dropping the water level below the level of the INLETS, blowing or draining all of the water out of the pipes, adding antifreeze, and closing off both ends. Pipes should be drained or winterized in regions where freezing temperatures are expected to be reached inside of the pipes. This should not be done with car antifreeze, and the antifreeze should not be toxic to humans.

5.7.1.7 Strainers and Pumps R&F

5.7.1.8 Flow Meters R&F

Flow meters are important for the maintenance of proper filtration, backwashing, and recirculation flow rates. It is also feasible to save money on electrical costs by using the flow meter to monitor and adjust the speed of the pump.

5.7.1.9 Flow Rates/Turnovers R&F

5.7.2 Filtration

5.7.2.1 Granular Media Filters R&F

5.7.2.1.4 Backwashing Frequency R&F

Backwashing frequency is important for multiple reasons. First, solids attach more strongly to the filter media over time and can be more difficult to remove following infrequent backwashing. Secondly, the organic particles (e.g., skin cells) held in the filter in contact with free CHLORINE can break down over time and produce DISINFECTION BY-PRODUCTS and/or combined CHLORINE. The potential to form “mudballs” also increases with solids loading inside of a filter and can cause filter failures. The preceding items are the rationale for requiring backwashes at prescribed pressure losses through the filter as well as at prescribed time intervals. Some data suggests tainted backwash water remains inside of the filter at the conclusion of the backwash procedure and therefore should be wasted to drain for at least the first 2 minutes after restarting.

5.7.2.1.7 Filtration Enhancing Products R&F

Coagulants should be used with caution due to potential for filter bed fouling. Maintaining records of clean bed headloss is recommended to help detect problems of filters not being adequately cleaned via backwashing. If a facility decides to use coagulants, they should be used continuously. Not using coagulants when the water is clear to save money will significantly impair the capabilities of the filters to remove pathogens like *Cryptosporidium* and *Giardia*.

5.7.2.2 Precoat Filters**R&F****5.7.2.2.2 Precoating****R&F**

In closed-loop mode, it will be necessary to charge the media slurry to the suction side of the pump or precoat tank, prior to closing down the loop and putting the system into recirculation. Precoating of a filter typically takes 5 to 10 minutes. At the end of the precoat cycle, the discharge out of the filter should be clear and free of filter media. If the discharge is not clear, the filter should be opened, inspected, and repaired as necessary.

5.7.2.2.3 Operation**R&F**

When flow or pressure is lost in the filter, the precoat layer may become unstable and fall off of the filter septum. To reduce the likelihood of debris and CONTAMINANTS being returned to the POOL, it is recommended that prior to restarting the filter, it should be backwashed and/or cleaned and the precoat re-established with new filter media in a closed loop recirculation mode or with water wasting until the discharge of the filter is clear to minimize the potential of media or debris returning to the POOL. It is important that flow not be interrupted after the precoating process is completed and the flow out of the filter is redirected from the recirculation or waste piping back to the POOL. It is acceptable to open and close valves on the filter effluent stream as long as the closed valves are opened first so that the filter effluent water can flow continuously. Allowing the media to fall off of the filter septum decreases the capability of the filter to remove particles. The critical importance of always cleaning the filter and replacing the media when the flow is interrupted for any reason is related to uneven recoating permitting pathogen passage as well as fouling of the media support layers.²⁹⁹

5.7.2.2.4 Cleaning**R&F**

Septum covers should be properly cleaned and inspected to maintain proper performance of precoat filters. Filters should be backwashed following a significant drop in the flow rate or when the pressure differential across the filter is greater than 10 pounds per square inch (68.9 KPa). Vacuum-type precoat filters should be cleaned when the vacuum gauge reading increases to greater than 8 inches (203 mm) of mercury or as recommended by the manufacturer. If after precoating with fresh media, the filter pressure does not return to the normal initial starting pressure noted on filter start-up, it would be advisable to disassemble the filter and clean the elements (septum covers) per the filter manual. Septum covers should be cleaned or replaced when they no longer provide effective filtration or create a friction loss preventing maintenance of the recommended recirculation rate. Water and spent media should be discharged in a manner approved by the appropriate regulatory agency.

5.7.2.2.6 Bumping**R&F**

Bumping is the act of intentionally stopping the filter and forcing the precoat media and collected CONTAMINANTS to be removed from the filter septum. Bumping may impair pathogen removal and could facilitate the release of pathogens previously trapped in

²⁹⁹ Cleasby JL and Logsdon GS. Chapter 8: Granular Bed and Precoat Filtration. In Water Quality and Treatment, 5th Ed. McGraw Hill, Inc. NY:1999. ISBN: 0070016593.

the filter. Therefore, bumping should be performed in accordance with the manufacturer's recommendations. Prior to restarting a bumped filter, it is recommended that the precoat be re-established in a closed loop recirculation mode or with water wasting until the discharge of the filter is clear to minimize the potential of media or CONTAMINANTS returning to the POOL.

Pending future research, bumping is strongly discouraged in any precoat filter application where pathogen removal is a concern. Bumping may impair pathogen removal as pathogens once trapped at the surface of the cake could be positioned close to the septum and penetrate the filter during operation.³⁰⁰ Cyst-contaminated water used for precoating filters led to much higher cyst concentrations in the filter effluent.¹⁹ Precoat filters have been demonstrated to remove greater than 99% of the OOCYSTS as shown in MAHC Annex Figure 4.7.2.5. Not using dirty precoat media to precoat filters as well as maintaining continuous flow is recommended.^{301,302,303}

5.7.2.2.7 Filter Media

R&F

Continuous filter media feed (or body-feed) can be used to increase the permeability of the cake, maintain flow, and extend cycle length as it becomes coated with debris. Body-feed is filter media added during the normal filtration mode on a continuous basis. The amount of body-feed used is dependent upon the solids loading in the POOL. Turbidity is the best available method to quantify and estimate solids loading. For filter influent turbidities greater than 1.5 NTU, body-feed may be beneficial with addition rates ranging from 1.0 to 4.0 ounces of DE per square foot of filter area per day dependent on the solids loading in the POOL. The lowest effective concentration of suspension should be used in a body-feed system. The concentration of the suspension may not exceed 5% by weight. The body-feed system head and lines should be flushed once every 15 minutes for at least one minute to assure proper and continuous operation. Water from the discharge side of the recirculation pump may be used. If connection is to a potable water supply line, the supply line should be equipped with an approved BACKFLOW prevention device.

Precoat media should normally be fed into the filter at a concentration not to exceed 5% by weight. Since perlite is approximately half the density of DE, half of the weight of perlite will achieve a similar depth of media inside of the filter as shown in MAHC Annex Table 5.7.2.2.7.1.

Table 5.7.2.2.7.1: Required Use Rates for Precoat Media

R&F

³⁰⁰ Logsdon GS et al. Alternative filtration methods for removal of *Giardia* cysts and cyst models. Journal AWWA. 1981;73(2):111-118.

³⁰¹ Croll BT, Hayer CR, and Moss S. Simulated Cryptosporidium removal under swimming pool filtration conditions. Water Environment Journal. 2007;21:149-156.

³⁰² Letterman RD. Water Quality and Treatment. 1999. 5th Ed. McGraw-Hill, NY.

³⁰³ Cleasby JL and Logsdon GS. Chapter 8: Granular Bed and Precoat Filtration. In Water Quality and Treatment, 5th Ed. McGraw Hill, Inc. NY:1999. ISBN: 0070016593.

Media Type	Pounds per 10 ft ² of filter area	Approximate Precoat Depth
DE	1.0 - 2.0	1/16 th – 1/8 inch
Perlite	0.5- 1.0	1/16 th – 1/8 th inch

5.7.2.2.7.1 Diatomaceous Earth

R&F

Drinking water applications typically recommend using DE at application rates of 0.2 lbs/ft² (1 Kg/m²).^{32, 304} This practice seems to be based on research showing that the removal of 9-micron (*Giardia*-sized) microspheres increased from greater than 99% to greater than 99.9% as the precoat amount increased from 0.5 to 1 Kg/m².³⁰⁵ Under the range of conditions tested, Logsdon and coworkers³⁰⁶ found that the amount of DE had a greater impact on microsphere removal than did the grade of DE.

Alum-coated DE has been shown to significantly improve the removal of turbidity and bacteria not normally removed by DE filters.³⁰⁷ Logsdon³⁰⁸ reported that alum could be added at 0.05 g of alum as Al₂(SO₄)₃ · 14 H₂O per 1 g of DE in a slurry to form a precipitate on the surface to enhance performance.

5.7.2.2.8 Water Clarity and Visibility

R&F

5.7.2.3 Cartridge Filters

R&F

5.7.2.3.1 NSF Standards

R&F

Cartridge filter elements should be cleaned (or replaced) when the differential pressure across the filter exceeds 10 psi (69 KPa). Every cartridge filter should have two sets of cartridges. This will allow for one set to be in use while the other is being cleaned (soaking and drying are recommended).

5.7.2.3.2 Filtration Rates

R&F

The 0.375 gallons per minute per square foot (0.26 L/s/m²) maximum design flow rate is acceptable, but an allowance is necessary to accommodate irreversible fouling of

³⁰⁴ Cleasby JL and Logsdon GS. Chapter 8: Granular Bed and Precoat Filtration. In Water Quality and Treatment, 5th Ed. McGraw Hill, Inc. NY:1999. ISBN: 0070016593.

³⁰⁵ Croll BT, Hayer CR, and Moss S. Simulated Cryptosporidium removal under swimming pool filtration conditions. Water Environment Journal. 2007;21:149-156.

³⁰⁶ Logsdon GS et al. Alternative filtration methods for removal of *Giardia* cysts and cyst models. Journal AWWA. 1981;73(2):111-118.

³⁰⁷ Lange KP et al. Diatomaceous earth filtration of *Giardia* cysts and other substances. Journal AWWA. 1986;78(1):76-84.

³⁰⁸ Logsdon GS. Water filtration practices: including slow sand filters and precoat filtration. 2008. American Water Works Association, Denver, CO. ISBN: 9781583215951.

cartridges (i.e., cartridges that do not recover 100% of the original capacity when cleaned after fouling). Systems designed for a given TURNOVER time with a filter flow rate of 0.375 gallons per minute per square foot (0.26 L/s/m²) would not be in compliance if partially fouled cartridges dropped the flow rate to 0.30 gallons per minute per square foot (0.20 L/s/m²). Therefore, an acceptable operating range is provided beyond which cartridge replacement would be necessary.

5.7.2.3.3 Filter Elements

R&F

Cartridges should be cleaned when the gauge pressure differential is 10 psi (69 KPa) and in accordance with manufacturer's instructions. Cleaning equipment should include a soaking container properly sized to immerse the filter elements, a rinsing area with proper drainage, and a drying area protected from contamination (e.g., birds and insects). New filters do not regain 100% of their capacity. Perhaps only about 80% of the capacity is recoverable, regardless of the treatment. If the recommended design flow rate exceeds 80% of the maximum flow allowed on the filter, the filter may be undersized.

5.7.2.3.3.1 Cleaning Procedure

R&F

Facilities with cartridge filters are recommended to have the equipment on-site to clean the cartridges. This includes a basin or tub large enough immerse the entire cartridge in. Water from the cleaning and soaking process must be discharged to the sanitary sewer. Proper cleaning is critical. Failure to clean the cartridge properly can lead to disease outbreaks.

Cartridge Cleaning

R&F

To clean the cartridges:

1. **RINSE THOROUGHLY** - Rinse the cartridge of as much dirt and debris as possible by washing inside and out with a garden hose and spray nozzle – DO NOT use a pressure washer. High flow/pressure can drive the dirt into the interior and permanently damage it
2. **DEGREASE** - Cartridge filters need to be degreased each time they are cleaned. Body oil, suntan oil, cosmetics, hair products and/or algae and biofilms can form a greasy coating on the filter pleats, which will clog the pores and reduce the filter capacity.
 - a. Soak the cartridge overnight in filter cleaner/degreaser OR a solution of water with 1 cup of TSP (tri-sodium phosphate) OR 1 Cup of automatic dishwashing detergent per 5 gallons of water.
 - b. **NEVER USE MURIATIC ACID OR PRODUCTS WITH ACID IN THEM PRIOR TO DEGREASING. ACID MAY PERMANENTLY SET THE GREASE AND RUIN THE CARTRIDGE.**
3. RINSE THOROUGHLY
4. **SANITIZE** - To remove or prevent biofilms, algae and bacteria growing on the cartridge, add 1 quart of household bleach per 5 gallons of clean water and soak one hour before rinsing.

5. **RINSE** - Remove the clean cartridge from the sanitization soak water and rinse thoroughly with a hose.
6. **DRY**- After the filter is cleaned and degreased it should be allowed to dry completely. Some bacteria (e.g., *LEGIONELLA* spp.) that survive the cleaning process can be killed by drying. Do not allow the filter to become contaminated with dirt or soil after it is cleaned. Put the cartridges in a clean plastic trash bag if they are to be transported and the original boxes are not available.
7. **ACID WASH** – ONLY IF NECESSARY - Excessive calcium or mineral deposits on the filter media can be cleaned with a 1:20 solution of clean water and Muriatic Acid. Put a few drops of muriatic acid on the filter. If it foams, it might need to be acid washed. Very few filters need to be acid washed.

5.7.2.3.3.2

Pressure Washer

R&F

A pressure washer should not be used as high flow/pressure can drive the dirt into the interior and permanently damage the cartridge or can aerosolize pathogens in the filter biofilm, which exposed and infected workers when cleaning the cartridge filters in an enclosed space³⁰⁹.

5.7.3. Disinfection

5.7.3.1 Primary Disinfectants

DWQ

5.7.3.1.1 Chlorine (Ca/Na/Li Hypochlorite)

DWQ

5.7.3.1.1.2 Minimum FAC Concentrations

DWQ

It is necessary to ensure that FAC is maintained at or above the 1.0 PPM (MG/L) minimum level at all times and in all areas of the POOL. Because CHLORINE efficacy is reduced in the presence of cyanuric acid, higher FAC levels may be necessary for POOLS using cyanuric acid or stabilized CHLORINE.

The minimum FAC level of 1.0 PPM (MG/L) for swimming POOLS is well-supported by available data. The CDC website data indicates that a 1.0 PPM (MG/L) FAC residual can provide effective DISINFECTION of most pathogens other than *Cryptosporidium*.³¹⁰

³⁰⁹ Moraga-McHaley SA et al. Hypersensitivity pneumonitis with Mycobacterium avium complex among spa workers. J Occup Environ Health. 2013;19(1):55-61.

³¹⁰ Centers for Disease Control and Prevention (CDC). Chlorine Disinfection Timetable. Last modified May 07, 2010. Accessed February 6, 2012. <http://www.cdc.gov/healthywater/swimming/pools/chlorine-disinfection-timetable.html>.

Germ Inactivation for Chlorinated Water*	
Germ	Time
<i>E. coli</i> O157:H7 Bacterium	Less than 1 minute
Hepatitis A Virus	About 16 minutes
<i>Giardia</i> Protozoan	About 45 minutes
<i>Cryptosporidium</i> Protozoan	About 15,300 minutes (10.6 days)
* Laboratory testing results using CHLORINE demand free water with 1 PPM (MG/L) (1MG/L) CHLORINE at PH 7.5, 77° F (25° C) and in the absence of Cyanuric acid.	

Substantial laboratory data shows that kill times for microbial CONTAMINANTS are increased in the presence of cyanuric acid. However, the precise impacts on CT VALUES in a swimming POOL environment are not well-established. In general, studies show that the presence of CYA up to 50 MG/L increase CT VALUES under demand free conditions, and the amount of this increase depends upon the pH and the ratio of CYA to available CHLORINE. Studies suggest that this effect is mitigated with the addition of ammonia nitrogen as low as 0.05 MG/L.

Swimming POOL survey data demonstrates that 1.0 PPM (MG/L) FAC provides acceptable bacteriological quality.³¹¹

However, another paper suggests that free CHLORINE levels significantly higher than 1.0 PPM (MG/L) may be required. Based on data collected from seven chlorinated POOLS, Ibarluzea et al predicted that 2.6 PPM (MG/L) is needed “in order to guarantee, with a probability of 90%, the acceptability of bathing water at indoor chlorinated swimming-POOLS.”³¹²

A minimum FAC level (3.0 PPM (MG/L)) for SPAS addresses the higher BATHER LOAD, higher temperatures and/or at-risk populations served by these venues. The BATHER LOAD and temperatures of these venues favor microbial growth and can lead to rapid depletion of CHLORINE. This minimum requirement is consistent with CDC recommendations to minimize transmission of Legionnaires disease from whirlPOOL SPAS on cruise ships, published in 1997, which recommends maintaining free residual CHLORINE levels in SPA water at 3 to 10 PPM (MG/L). It is further supported by a study reviewing both bromine and CHLORINE, which states, *Pseudomonas aeruginosa* were rapidly reestablished in SPAS (< 10³ cells per ml) when disinfectant concentrations decreased below recommended levels [CHLORINE, 3.0 PPM (MG/L), bromine 6.0 PPM (MG/L)].³¹³

³¹¹ Esterman A et al. Determinants of the microbiological characteristics of South Australian swimming pools. Appl Environ Microbiol. 1984 February; 47(2): 325-328.

³¹² Ibarluzea, J et al. Determinants of the microbiological water quality of indoor swimming pools in relation to disinfection. Water Research. 1998; 33(3): 865-871.

³¹³ Price D, Ahearn DG. Incidence and persistence of *Pseudomonas aeruginosa* in whirlpools. J Clin Microbiol. 1988

In general, a range of 2-4 PPM (MG/L) FAC for POOLS (3-5 PPM (MG/L) for SPAS) is recommended to help ensure the minimum FAC is maintained and to provide a margin of SAFETY for BATHERS.

For individual POOLS, considerations for ideal FAC levels include:

- **Chlorine demand:** FAC levels should be sufficient to accommodate peak BATHER LOADS and other sources of contamination.
- **Temperature and sunlight:** FAC levels should be sufficient to accommodate loss of FAC from higher water temperatures and sunlight.
- **Cyanuric acid:** Because CHLORINE efficacy is reduced in the presence of cyanuric acid, higher FAC levels may be necessary for POOLS using cyanuric acid or stabilized CHLORINE. ^{314,315,316, 317}
- **Algae control:** Algae is more difficult to control than most pathogens and may require FAC residuals >3.0 PPM (MG/L) although peer-reviewed data is lacking.
- **Accuracy of FAC tests:** POOL test kits have been reported to give FAC results which diverge significantly from true values although peer-reviewed data is lacking.
- **Feeder equipment:** Automated feeders help reduce variability in dosing and the potential for FAC levels to fall below minimum levels.
- **Secondary disinfection:** While the minimum FAC level must be maintained in all POOLS, approved SECONDARY DISINFECTION SYSTEMS such as UV and ozone reduce risks from CHLORINE-resistant pathogens and may reduce CHLORINE demand. However, the effects of UV/CHLORINE on water chemistry are still largely undefined. Recent research suggests that UV can increase some forms of CHLORINE demand.

Maximum FAC

DWQ

FAC levels should be consistent with label instructions of the disinfectant. All POOL and SPA disinfectants must be registered by the U.S. Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide and Rodenticide Act. MAHC Committees welcome input and supporting data for establishing upper limits.

EPA has not approved any POOL product use above 4 PPM (mg/L) FAC or SPA product use above 5 PPM (mg/L) FAC when BATHERS are present. The maximum FAC level approved for POOLS is consistent with EPA's Maximum Residual Disinfectant Level (MRDL) of 4 PPM (mg/L) for drinking water.

Sep;26(9):1650-4.

³¹⁴ Anderson JR. A study of the influence of cyanuric acid on the bactericidal effectiveness of chlorine. Am J Public Health Nations Health. 1965 Oct;55(10):1629-37.

³¹⁵ Fitzgerald GP, DerVartanian ME. Factors influencing the effectiveness of swimming pool bactericides. Appl Microbiol. 1967 May;15(3):504-9.

³¹⁶ Golaszewski G et al. The kinetics of the action of chloroisocyanurates on three bacteria: *Pseudomonas aeruginosa*, *Streptococcus faecalis*, and *Staphylococcus aureus*. Water Research 1994;28(1): 207-217.

³¹⁷ Fitzgerald GP et al. *Pseudomonas aeruginosa* for the evaluation of swimming pool chlorination and algicides. Appl Microbiol. 1969 Mar;17(3):415-21.

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No data was identified suggesting health risks from FAC levels at, or even significantly above, these levels. The EPA MRDL and the World Health Organization's drinking water guideline value for CHLORINE (5 PPM (mg/L)) are based on drinking water studies that found no adverse effects related to CHLORINE³¹⁸.

Use of high levels of CHLORINE as a "shock dose" when BATHERS are not present may be part of an overall water quality management strategy. Periodic shock dosing can be an effective tool to maintain microbial quality of water and to minimize build-up of biofilms and inorganic chloramines. For BATHER re-entry, FAC levels shall be consistent with label instructions of the disinfectant.

Salt water (saline) chlorination systems generate and deliver a CHLORINE disinfectant on-site directly into POOL water.

While cell size and configuration of these systems may differ depending on the manufacturer, the principles of their operation remain the same. Sodium chloride is added to balanced POOL water to establish a saline solution, which flows through the electrolytic cell. A low voltage electrical charge is passed through the saline solution and the current breaks the sodium and chloride bonds resulting in the formation of CHLORINE gas, hydrogen gas, and sodium hydroxide:



The hydrogen gas is dissolved in the water and eventually vents to the atmosphere. The CHLORINE gas then dissociates into hypochlorous acid (HOCl), which provides a residual of FREE AVAILABLE CHLORINE (FAC):



Salt water chlorination units should be sized appropriately to maintain minimum FAC levels during maximum load periods. The units should ideally be controlled by an ORP controller. Operators must still test the FAC residual of the water to ensure that the cell is producing adequate CHLORINE for the POOL. However, a separate chlorinating product may be needed to provide a sufficiently high FAC level for shock treatment or remediation following a fecal accident.

MONITORING and maintaining the pH, total alkalinity, and TDS of the water in the POOL is important. Salt water POOLS intentionally have high concentrations of sodium chloride. The sodium chloride will contribute to TDS, but will not cause decreased disinfectant efficacy or cloudy water.

Electrolytic cells do wear out and need to be replaced. The life of the cell depends upon how many hours the cell operates each day, the pH of the water, and the calcium

³¹⁸ WHO 2003. Chlorine in drinking water background document for development of WHO guidelines for drinking-water quality. WHO/SDE/WSH/03.04/45. World Health Organization, Geneva. Accessed at http://www.who.int/water_sanitation_health/dwq/chlorine.pdf

content of the water. The cells have to be cleaned to remove scale build-up. The systems usually utilize reversal of the polarity on the cells to minimize the scale formation, but eventually the cell will have deposits that require the cell to be removed from the plumbing and soaked in an acid solution.

The cells are also vulnerable to damage if they are operated in conditions of lower than recommended salt residuals or in water that is too cold. The systems have sensors and cut-offs to prevent this damage, but operators must be sure to monitor the unit to recognize when there is a problem.

5.7.3.1.2 Bromine

DWQ

5.7.3.1.2.1 EPA Registered

DWQ

The US EPA Office of Pesticides registers products and approves labels for bromine. Currently bromine products on the market for use in recreational water are registered with use levels ranging from 1-8 PPM (MG/L), depending on the product. The efficacy of these products have been studied by the manufacturers and submitted to the USEPA under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). The efficacy data analyzed by the US EPA is company confidential and has not been reviewed as part of the development of the MAHC. The MAHC Committees welcome input and supporting data for establishing upper limits.

5.7.3.1.2.2 Minimum Bromine Concentrations

DWQ

Bromine concentrations established by state and local jurisdictions have not been found to correlate with data supporting the concentrations being used. However, every state or local jurisdiction that allows bromine as a disinfectant requires bromine at higher concentrations than CHLORINE and almost twice as much in SPAS and warmer POOLS.

Commercially available test kits are not capable of distinguishing free bromine (Br_2 , HOBr , OBr^-) from combined bromine (bromamines). The bromine value specified in test results is the concentration of total bromine, not the free available halogen that is tested with CHLORINE. To determine total bromine, test kit manufacturers use a CHLORINE value and multiply it by 2.25. The 2.25 conversion factor accounts for the molecular weight difference between elemental bromine and elemental CHLORINE ($\text{Br} = 79.90$ grams per mole and $\text{Cl} = 35.45$ grams per mole). Further, presently used field test kits assay only for total bromine.

Bromine is commonly used in indoor commercial SPAS, probably due to these two factors. First, bromamines (bromine and ammonia combined) do not produce irritating odors as do chloramines. Second, bromine efficacy is less impacted than CHLORINE's at a higher pH, which typically occurs in a SPA environment. At pH of 7.5, 94% of bromine is hypobromous acid, whereas at the same pH, hypochlorous acid is 55% in chlorinated water. At pH of 8.0 bromine still has 83% hypobromous acid, while in a chlorinated water, hypochlorous acid is 28%.³¹⁹

³¹⁹ White GC. 1999. Handbook of chlorination and alternative disinfectants. 4th ed.: John Wiley and Sons, Inc. New

Bromine is also not very common in outdoor POOLS because like CHLORINE, bromine is destroyed rapidly in sunlight. Cyanuric acid was developed to combat the problem in chlorinated POOLS, but does not provide a stabilizing effect for bromine.

While reviewing the literature and surveillance data from CDC, evidence that outbreaks have occurred when required minimum bromine concentrations have been maintained is lacking. Therefore, in absence of any clear research, the decision to use common state requirements as the recommended levels is prudent.

SPAS have been implicated in many skin disease outbreaks throughout the years. One paper suggests that a common culprit, *Pseudomonas aeruginosa*, were rapidly reestablished in whirlPOOLS (<10³ cells per ml) when disinfectant concentrations decreased below recommended levels (CHLORINE, 3.0 PPM (MG/L), bromine, 6.0 PPM (MG/L)). The authors studied the reoccurrence of bacteria following cleaning and halogen shock treatment.³²⁰ This study emphasized the need for maintaining a consistent CHLORINE level in the SPA. CDC recommends 4-6 ppm for bromine.

The MAHC committee recommends a follow up study to evaluate the efficacy of bromine on *P. aeruginosa*, since it is so commonly found in SPAS; and because bromine is very common disinfectant used in SPAS, prevention and treatment is essential.

There are few peer-reviewed studies on bromine efficacy in real world POOLS and SPAS in the literature. Brown et al. reported reasonable bacterial control with 2.0 total bromine in an 118,000 gallon indoor POOL using BCDMH.³²¹ Normal day time BATHER LOADING was around 0.21 persons per 500 gallons per hour but often increased to as high as 0.85 in the evening. The POOL did not use supplemental OXIDATION but did replace 5% of the water daily which likely contributed to the low reported ammonia nitrogen and organic nitrogen. Shaw reports a retrospective analysis of brominated and chlorinated semi-public SPAS in Alberta.³²² The data used was from the microbiological results of the weekly samples required under provincial regulations. The treatment systems compared include BCDMH (OXIDATION method not specified), bromide salt regenerated by hypochlorous acid/potassium monopersulfate continuous feed, CHLORINE gas, hypochlorite (type not specified), dichlor, and trichlor. The concentrations were generally in line with provincial regulations of 2 PPM (MG/L) total bromine and 1 PPM (MG/L) free CHLORINE. The brominated SPAS had a higher failure rate in all three bacterial parameters. There were several complaints of both contact dermatitis and *Pseudomonas* folliculitis from the brominated SPAS during the period studied but, due to the nature of the retrospective studies, it was not possible to link the reported RWIs to the concentration of the disinfectant at the time of the complaint. It appears from composite data that when semi-public SPAS are operated using the US EPA minimum halogen concentration of 1.0 PPM (MG/L) free CHLORINE or 2 PPM (MG/L) total bromine

York.

³²⁰ Esterman A et al. Determinants of the microbiological characteristics of South Australian swimming pools. Appl Environ Microbiol. 1984 February; 47(2): 325-328.

³²¹ Brown JR et al. Bromine disinfection of a large swimming pool. Can J Public Health. 1964 Jun;55:251-6.

³²² Shaw JW. A retrospective comparison of the effectiveness of bromination and chlorination in controlling *Pseudomonas aeruginosa* in spas (whirlpools) in Alberta. Can J Public Health. 1984 Jan-Feb;75(1):61-8.

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that *Pseudomonas aeruginosa* can be isolated from the brominated SPAS at greater than twice the frequency than from chlorinated SPAS.

Bromates

DWQ

Ozone and bromide ions in water form hypobromous acid and bromate ions. Bromates have been classified by the International Agency for Research on Cancer (IARC) as having sufficient evidence of carcinogenicity in laboratory animals. As a result, WHO has set a provisional drinking water guideline value of 10 ug/L. The USEPA has established a maximum CONTAMINANT level of 10 ug/L for bromate in drinking water.

BCDMH (1-bromo-3-chloro-5, 5-dimethylhydantoin) is the most common form of bromine used in commercial POOLS and SPAS today. The function of DMH is to inhibit the formation of bromates.

At present there is little information on the functionality of using DMH in this manner. Since there is not a convenient field test kit an operator has no way of knowing what the DMH level is in the water or when it may go below 10 PPM (MG/L) to allow bromates to form. We also don't know what the maximum safe level of DMH should be. To rely on DMH for bromate prevention, suitable test methods and further research are necessary.

Operators should consider that ozone should likely not be used with bromine systems when there is a substantial likelihood of ingestion of the water. When ozone is used in conjunction with organic bromine sources (BCDMH or DBDMH---another common source of bromine), the ozone readily converts residual bromide ion back to hypobromous acid. This process reduces ozone. With the continued addition of BCDMH, DBDMH, or sodium bromide, the bromide levels will continue to climb in the POOL or SPA. Continuous build-up of bromide will constantly reduce ozone; diminishing ozone's effective OXIDATION (and destruction) of organics and microorganisms in the water. Because of the wide variation in the concentration of bromide and the potential for bromate ingestion at least one ozone manufacturer does not recommend the installation of ozone units in bromine-treated facilities.

Disinfection

DWQ

DISINFECTION using bromine is more complex but less well documented than DISINFECTION using CHLORINE. Hypobromous acid is the putative biocidal chemical species at recreational water pH. Hypobromous acid reacts with inorganic ammonia and forms monobromamine, dibromamine, and nitrogen tribromide, depending on the pH and concentration of ammonia.³²³ These inorganic bromamines are all considered more biocidal than their corresponding CHLORINE analogs. Hypobromous acid is converted to inert bromide ion upon biocidal action in a manner similar to that seen with hypochlorous acid. One key difference between bromine and CHLORINE DISINFECTION is that bromide is readily oxidized back to hypobromous acid and chloride is not. Further, hypobromous acid is a much weaker oxidizer than hypochlorous acid. As a consequence of these two differences, exogenous OXIDATION of brominated waters (e.g.

³²³ Galal-Gorchev H et al. Formation and stability of bromamide, bromimide, and nitrogen tribromide in aqueous solution. Inorganic Chemistry. 1965;4(6):899-905.

shocking with CHLORINE) is more important for safe operation than it is in chlorinated waters. In reviewing the published epidemiological studies on RWIs it is often difficult to determine the exact treatment system used because the SUPPLEMENTAL TREATMENT SYSTEM is not described. Further, presently used field test kits assay only for total bromine and are not capable of distinguishing free bromine from biocidal inorganic bromamines or from non-biocidal organic bromamines.

Bromamines

DWQ

CURRENT POOL and SPA operating manuals state that combined bromine (bromamines) is as efficacious as free bromine. This may be an over generalization of the complex nature of bromine chemistry. Bromine reacts with inorganic ammonia and forms analogous compounds (Br₂, hypobromous acid, monobromamine, dibromamine, and nitrogen tribromamide) depending in the pH and concentration of ammonia.³³ All three bromine-ammonia derivatives are biocidal but all three are also less stable than their corresponding CHLORINE compounds. As with their CHLORINE analogs, the ratios of the bromamines are highly dependent on the ratio of ammonia to bromine. Further, at low ammonia to bromine ratios the biocidal action appears to be substantially reduced³²⁴. The levels of ammonia that result in loss of bromine efficacy have been detected in SPA water³²⁵. At these documented concentrations of bromine and ammonia the predominant bromamine is most likely dibromamine, which has an estimated half-life of 10 minutes³²⁶. The MAHC committee was not able to locate data on the efficacy of organic bromamines.

Future Research Needs

DWQ

Cryptosporidium Inactivation

DWQ

Methods to hyper-brominate recreational water in response to diarrheal fecal accidents have not been established. Inactivation of *Cryptosporidium* using hypobromous acid has been shown to be approximately three times higher than what is found with CHLORINE and therefore would require 22 hours for 30 PPM (MG/L) bromine at pH 7.5 for a 3 log reduction (unpublished CDC data). Whether all inorganic bromamines are equally as oocysticidal as hypobromous acid is not known. A method to hyper-brominate to the 30 PPM (MG/L) hypobromous acid treatment would need to consider the oxidizer demand from organics which often accumulates in bromine systems as well as the oxidizer demand from the large bank of bromide ions that are known to accumulate with BCDMH and DBDMH systems. Research in this area is lacking.

Bromine Associated Rashes

DWQ

Note to readers: These comments have been inserted to point future researchers toward an under-investigated area of public health and are not meant to imply a negative bias toward bromine.

³²⁴ Wyss O et al. The germicidal action of bromine. Arch Biochem. 1947 Feb;12(2):267-71.

³²⁵ Kush BJ et al. A preliminary survey of the association of *Pseudomonas aeruginosa* with commercial whirlpool bath waters. Am J Public Health. 1980 Mar;70(3):279-81.

³²⁶ Johnson JD et al. Bromine and bromamine disinfection chemistry. J of Sanitary Engineering Division Am Soc of Civil Eng, 1971;97:617-628.

Literature reviews demonstrate a large number of reports describing rashes associated with brominated water. These rashes fall into two general categories:

- contact dermatitis due to brominated species in the water, and
- dermal infections due to *Pseudomonas aeruginosa*.

These are most easily differentiated by incubation time. The vast majority of contact dermatitis reactions occur within 24 hours of immersion, sometimes within minutes. These are often referred to as “bromine itch” and are widely reported in the medical literature^{327,328,329}. In most cases the putative etiological agent is thought to be bromamines. This type of dermatitis appears to be a result of cumulative exposure to bromine treated water and is particularly prevalent among medical personnel provide aquatic physical therapy³³⁰. The exact compounds inducing contact dermatitis have not been identified. One study strongly suggests that the use of bromine with supplemental OXIDATION minimizes contact dermatitis³³¹. In numerous epidemiological studies poor water quality is commonly, but not always, reported (Woolf and Shannon report an extreme example of a foamy POOL leading to multiple cases of contact-related RWI³³²). The typical incubation period for *Pseudomonas aeruginosa* folliculitis is several days but can be as short at 24 hours. Outbreaks of *Pseudomonas aeruginosa* folliculitis are routinely associated with inadequate sanitation in both chlorinated and brominated waters. The minimum concentration to prevent such outbreaks has not been established but appears to at least 1 PPM (MG/L) free CHLORINE and 2 PPM (MG/L) total bromine. A survey of the literature since the mid-1980s shows more dermal RWI outbreaks reported in brominated waters than in chlorinated waters. It is not known whether the reports reflect the true incidence, a bias in reporting of bromine systems, or a bias in reporting RWIs in SPAS, which tend to use bromine disinfectants.

There are many unanswered questions surrounding bromine-treatment systems commonly used in AQUATIC VENUE DISINFECTIONS. After reviewing the literature, the committee has concluded the following research is essential to understanding bromine DISINFECTION.

Further research needs to address, in priority order:

- The efficacy of bromine to establish a minimum concentration for AQUATIC VENUES and warm water SPAS and THERAPY POOLS,
- The maximum bromine concentration that should be allowed,

³²⁷ Rycroft RJ et al. Dermatoses associated with brominated swimming pools. Br Med J (Clin Res Ed). 1983 Aug 13;287(6390):462.

³²⁸ Fitzgerald DA et al. Spa pool dermatitis. Contact Dermatitis. 1995 Jul;33(1):53.

³²⁹ Loughney E et al. Irritant contact dermatitis due to 1-bromo-3-chloro-5,5-dimethylhydantoin in a hydrotherapy pool. Risk assessments: the need for continuous evidence-based assessments. Occup Med (Lond). 1998 Oct;48(7):461-3.

³³⁰ Lazarov A et al. Self-reported skin disease in hydrotherapists working in swimming pools. Contact Dermatitis. 2005 Dec;53(6):327-31.

³³¹ Kelsall HL et al. Skin irritation in users of brominated pools. Int J Environ Health Res. 2001 Mar;11(1):29-40.

³³² Woolf A et al. Reactive airways dysfunction and systemic complaints after mass exposure to bromine. Environ Health Perspect. 1999 Jun;107(6):507-9.

- The contribution of bromamines to DISINFECTION and BATHER rashes,
- Methods to better control bromamines,
- Creation of a test kit to differentiate free bromine from combined (as is currently practiced with CHLORINE) in the water,
- Use of DMH in respect to bromate formation,
- Establish a safe maximum level,
- Creation of a test kit to establish levels in the water, and
- Fecal accident recommendations to control *Cryptosporidium* when using a bromine POOL.

5.7.3.1.3 Stabilizers

5.7.3.1.3.1 Cyanuric Acid (CYA)

DWQ

Cyanuric acid (CYA) is effective in protecting available CHLORINE from UV degradation. The chemical associates with CHLORINE to form chlorinated isocyanurates: trichlor (trichloroisocyanuric acid) and dichlor (sodium dichloroisocyanuric acid). It can also be added as a separate chemical in the form of isocyanuric acid, commonly referred to as cyanuric acid. Trichlor is commonly found as tablets or sticks. Dichlor is a granular material, as is the isocyanuric acid.

Products containing or forming cyanuric acid (CYA) must be clearly labeled and directions provided to the user for proper use, limitations, toxicity, cautions, and effects.

The most important factor in POOL DISINFECTION is the presence of sufficient levels of free CHLORINE. CYA acid helps maintain free CHLORINE levels in outdoor POOLS.

CYA acid is not a disinfectant so it is not registered by the EPA. Stabilized CHLORINES are registered with the EPA as disinfectants; however, EPA has not reviewed efficacy data on CHLORINE in the presence of stabilizer to date. The EPA reviewed efficacy data on dichlor and trichlor when it approved registrations for drinking water DISINFECTION. However, these data are not directly applicable to swimming POOLS where repeated doses lead to higher CYA levels.

Minimum Disinfection

DWQ

Minimum CHLORINE levels should be increased by a factor of at least two when using CYA. Robinton et al found that "50 MG/L of cyanuric acid produced pronounced retardation of the bactericidal efficiencies of solutions of calcium hypochlorite, trichloroiso-cyanuric acid, and potassium dichloroisocyanurate such that a four- to eightfold increase in the amount of "free" available residual CHLORINE may be necessary to attain the same degree of inactivation of the same organisms in the same interval of time."³³³

Laboratory studies by Warren and Ridgway show that addition of 50 MG/L cyanuric acid to 0.5 - 1.0 MG/L available CHLORINE resulted in a significant increase in CT

³³³ Robinton ED et al. An evaluation of the inhibitory influence of cyanuric acid upon swimming pool disinfection. Am J Public Health. 1967 Feb;57(2):301-10.

Staphylococcus aureus, in parallel with the increase in available CHLORINE stability in sunlight. However, higher concentrations of cyanuric acid resulted in little to modest further increases in CT over that for 50 MG/L cyanuric acid. For example, the data suggest that for 50, 100 and 200 MG/L of cyanuric acid, the level of CHLORINE required for 99% kill of *Staphylococcus aureus* in one minute would be 1.9, 2.15, and 2.5 MG/L, respectively.³³⁴

The MAHC has adopted a SAFETY factor of 2 so that 2 ppm is the minimum concentration of using stabilized products. More data are needed to understand the impact of increasing cyanurate levels on pathogen inactivation to assess what this level should be so the MAHC has adopted ≤ 100 ppm as has the World Health Organization³³⁵.

The level of cyanurate allowed in outdoor AQUATIC VENUES is double that for non-stabilized CHLORINE, which is a SAFETY factor for the decrease in oxidative capacity. The MAHC has decided that it cannot support from a public health standpoint a prohibition of the use of cyanurate in most INCREASED RISK AQUATIC VENUES. The SAFETY margin of two times the level of non-stabilized product would also apply for increased indoor settings in addition to the requirement for a SECONDARY DISINFECTION SYSTEM and therefore prohibition in an INCREASED RISK venue cannot, at this time, be supported with a public health argument. The exception to this is operation of SPAS and THERAPY POOLS, which have large issues with efficacy of agents against pathogens in biofilms (SPAS) and the use by high risk groups of patients (THERAPY POOLS). SPAS and THERAPY POOLS will, therefore, not be allowed to use cyanuric acid or stabilized CHLORINE products.

Users should be aware that if these AQUATIC VENUES using cyanuric acid or stabilized CHLORINE products have a fecal incident they will need to close for more prolonged periods for a diarrheal fecal incident and HYPERCHLORINATION, circulate water through a SECONDARY DISINFECTION SYSTEM, or replace the water in the AQUATIC VENUE per MAHC Section 6.5.3.2.1.1³³⁶.

Indoor Pools

DWQ

There appears to be no operational or public health reason for indoor AQUATIC VENUES to use CYA. It is a stabilizer for degradation from direct sunlight and so likely has limited benefits for indoor POOLS despite some operators claiming a benefit for indoor POOLS with large glassed areas. However, since the level of cyanurate allowed in outdoor AQUATIC VENUES is double that for non-stabilized CHLORINE which is a SAFETY factor for the decrease in oxidative capacity. The MAHC has decided that it cannot support from a public health standpoint a prohibition of the use of cyanurate in indoor settings. The SAFETY margin would also apply for indoor settings and therefore prohibition in an indoor

³³⁴ Warren IC et al. Swimming pool disinfection. Investigations on behalf of the Department of the Environment into the practice of disinfection of swimming pools during 1972 to 1975. Water Research Centre, Henly-on-Thames, England, 35 pp., Oct 1978.

³³⁵ World Health Organization. Guidelines for safe recreational water environments. Volume 2, Swimming pools and similar environments. 2006: 71. Accessed at: http://www.who.int/water_sanitation_health/bathing/srwe2full.pdf.

³³⁶ Shields JM, et al. The effect of cyanuric acid on the disinfection rate of *Cryptosporidium parvum* in 20-ppm free chlorine. J Water Health. 2009 Mar;7(1):109-14.

setting would require specific data on the direct impact in indoor settings since the MAHC allows it in outdoor settings.

CDC still does not recommend cyanuric acid use for indoor POOLS or hot tubs. The recommendation was underscored in a 2000 MMWR after investigating a *Pseudomonas dermatitis/folliculitis* outbreak associated with indoor POOLS and hot tubs in Maine, noting that cyanuric acid was added to an indoor POOL which reduces the antimicrobial capacity of free CHLORINE^{337,338}.

Users should be aware that if these AQUATIC VENUES using cyanuric acid or stabilized CHLORINE products have a fecal incident they will need to close for more prolonged periods for a diarrheal fecal incident and HYPERCHLORINATION, circulate water through a SECONDARY DISINFECTION SYSTEM, or replace the water in the AQUATIC VENUE per MAHC Section 6.5.3.2.1.1³³⁹.

Effects of Cyanuric Acid on Microbial Inactivation

DWQ

There are a large number of references on the effect of CYA on kill times (CT VALUES). In general, they show that the presence of CYA increase CT VALUES, and the amount of this increase depends on the pH and the ratio of CYA to available CHLORINE. However, there are few reports that relate specifically to the issue of what levels of available CHLORINE and cyanuric acid are required to maintain a swimming POOL in a biologically satisfactory state.

Studies examining the effect of cyanuric acid on the DISINFECTION capacity of CHLORINE show that using cyanuric acid or stabilized CHLORINE slows down the inactivation times on bacteria, algae, protozoa (*Naegleria gruberi* and *Cryptosporidium parvum*), and viruses. Yamashita et al concluded the addition of cyanuric acid increased the time needed for DISINFECTION of 12 virus types by a factor of 4.8-28.8 compared to free CHLORINE alone.^{340,341}

99.9% Inactivation time in buffer studies, 0.5 PPM (MG/L) FAC, 25 C

³³⁷ Fitzgerald GP et al. *Pseudomonas aeruginosa* for the evaluation of swimming pool chlorination and algicides. Appl Microbiol. 1969 Mar;17(3):415-21.

³³⁸ Centers for Disease Control and Prevention (CDC). *Pseudomonas dermatitis/folliculitis* associated with pools and hot tubs--Colorado and Maine, 1999-2000. MMWR Morb Mortal Wkly Rep. 2000 Dec 8;49(48):1087-91.

³³⁹ Shields JM, et al. The effect of cyanuric acid on the disinfection rate of *Cryptosporidium parvum* in 20-ppm free chlorine. J Water Health. 2009 Mar;7(1):109-14.

³⁴⁰ Yamashita T et al. Influence of cyanuric acid on virucidal effect of chlorine and the comparative study in actual swimming pool waters. Kansenshogaku Zasshi. 1988 Mar;62(3):200-5.

³⁴¹ Yamashita T et al. Virucidal effect of chlorinated water containing cyanuric acid. Epidemiol Infect. 1988 Dec;101(3):631-9.

Organism	No CYA, min	30 PPM (MG/L) CYA, min
Poliovirus 1	0.8	5.6
Coxsackievirus A24	0.5	14.4
Enterovirus 70	0.12	2.5
Adenovirus type 3	0.14	2.1

99.9% Inactivation time in POOL water studies, 1.0 PPM (MG/L) FAC, 25 C

Organism	No CYA, min	30 PPM (MG/L)CYA, min
Poliovirus 1	0.4	4.4

In a later study, Yamashita et al³⁴² found “Total plate counts ranged from 0 to 1 per ml in the swimming POOLS treated with sodium hypochlorite and 0 to 51 in those with trichloroisocyanurates. In 11 of 12 water samples of 3 swimming POOLS using trichloroisocyanurates, poliovirus type 1 survived after 2 min contact while in 5 samples poliovirus type 1 survived after 5 min contact. The researchers concluded this showed that the risk of viral infection is greater in swimming POOL water treated with chlorinated isocyanurates than that with sodium hypochlorite.

The addition of CYA similarly impaired the inactivation of poliovirus³⁴³. Cyanuric acid, used as CHLORINE stabilizer in swimming POOL waters, had a relatively minor effect on the algicidal efficiency of free CHLORINE³⁴⁴. There are few data regarding protozoa and the effect of CYA on inactivation though the DISINFECTION rate for *Naegleria gruberi* was reduced by cyanuric acid in laboratory-controlled CHLORINE demand free conditions³⁴⁵.

Shields et al³⁴⁶ extended the previous findings by demonstrating that cyanuric acid significantly decreases the rate of inactivation for *Cryptosporidium parvum* OOCYSTS. In this study a three-log reduction of OOCYSTS was found to take place in the presence of 20 PPM (MG/L) FAC. When 50 PPM (MG/L) CYA was introduced, the 10-hour kill rate was less than ½ log.

³⁴² Yamashita T et al. Microbiological and chemical analyses of indoor swimming POOLS and virucidal effect of chlorine in these waters. Nihon Koshu Eisei Zasshi. 1990 Dec;37(12):962-6.

³⁴³ Saita K et al. Effects of isocyanuric acid on the polio virus inactivation with hypochlorous acid. Jpn. J. Toxicol. Environ. Health 1998;44:442–450.

³⁴⁴ Sommerfeld MR, Adamson RP. Influence of stabilizer concentration on effectiveness of chlorine as an algicide. Appl Environ Microbiol. 1982 Feb;43(2):497-9.

³⁴⁵ Engel J P et al. Inactivation of *Naegleria gruberi* cysts by chlorinated cyanurates. Appl Environ Microbiol. 1983;46:1157–1162.

³⁴⁶ Shields JM et al. The effect of cyanuric acid on the disinfection rate of *Cryptosporidium parvum* in 20-ppm free chlorine. J Water Health. 2009 Mar;7(1):109-14.

Pseudomonas inactivation in the presence of CYA was also studied in POOL water and it was found that increased CYA concentrations lengthened the kill times. The effect of cyanuric acid was greater as the concentration of CHLORINE in the water decreased.³⁴⁷

Favero et al found that at free CHLORINE concentrations of more than 0.5 PPM (MG/L), *P. aeruginosa* was rarely found except in those POOLS which used sodium dichloroisocyanurate as a POOL disinfectant. Three private swimming POOLS using sodium dichloroisocyanurate as a POOL disinfectant were found to contain large numbers of the potential pathogen, *P. aeruginosa*³⁴⁸. Fitzgerald found concentrations of 25, 50, and 100 mg of cyanuric acid per liter had large effects on the *Pseudomonas* kill rate of 0.1 MG/L free CHLORINE but this effect diminished with increasing free CHLORINE content (0.25, 0.5 MG/L). Fitzgerald found concentrations of 25, 50, and 100 mg of cyanuric acid per liter had little effect on the kill rate of 0.5 mg of CHLORINE plus 0.1 mg of NH₄-N per liter; however, cyanuric acid did reduce the time required for 99.9% kills when tested in the presence of higher concentrations of ammonia.³⁴⁹ The basis for this finding should be explored further.

Fecal Accident Response

DWQ

The use of stabilized CHLORINE is not recommended for HYPERCHLORINATION in RWI outbreaks, or in response to fecal accidents. Present MAHC requirements for HYPERCHLORINATION and POOL remediation are ineffective for POOLS using cyanurate-stabilized CHLORINE. Estimated *Cryptosporidium* inactivation times are much longer, which will require substantially longer closure times³⁵⁰.

Toxicity

DWQ

The maximum CYA concentration of 50 PPM (MG/L) should be considered protective from a toxicological perspective. Using an assumption that 100 ml of POOL water is swallowed per swim session; the World Health Organization (WHO) concluded that CYA levels in POOLS should be below 117 PPM (MG/L). This is based on a tolerable daily intake (TDI) for anhydrous sodium dichloroisocyanurate (NaDCC) of 2 mg/kg of body weight, which translates into an intake of 20 mg of NaDCC (or 11.7 mg of CYA per day) for a 10 kg child. The US EPA SWIMODEL, relying on somewhat lower exposure assumptions, would yield a higher acceptable level for CYA.

Research

DWQ

Though the data shows using CYA increases the inactivation time of many pathogens, the MAHC committee would like to have a study done on specific pathogens and inactivation rates at differing CYA levels, up to 200 PPM (MG/L). Further research on the inhibitory effect of cyanuric acid on DISINFECTION should evaluate the level at which cyanuric acid can still protect CHLORINE from UV and also balance the inactivation rate of

³⁴⁷ Woolf A et al. Reactive airways dysfunction and systemic complaints after mass exposure to bromine. Environ Health Perspect. 1999 Jun;107(6):507-9.

³⁴⁸ Favero, MS et al. Use of staphylococci as indicators of swimming pool. Public Health Rep. 1964 Jan;79:61-70.

³⁴⁹ Fitzgerald GP et al. *Pseudomonas aeruginosa* for the evaluation of swimming pool chlorination and algicides. Appl Microbiol. 1969 Mar;17(3):415-21.

³⁵⁰ Shields JM, et al. The effect of cyanuric acid on the disinfection rate of *Cryptosporidium parvum* in 20-ppm free chlorine. J Water Health. 2009 Mar;7(1):109-14.

the most common AQUATIC VENUE pathogens. The effect of pH in the presence of cyanuric acid should also be investigated. Additionally, a test kit should be created to test lower and higher levels of CYA. The current products on the market are not very accurate and cannot read values lower than 30 PPM (MG/L) and higher than 100 PPM (MG/L). During RWI outbreaks, it is strongly recommended that the investigation team measure CYA levels.

5.7.3.1.4 Compressed Chlorine Gas

R&F

Installation/use of compressed CHLORINE gas is prohibited for new AQUATIC FACILITIES; however there are existing facilities that continue to use these gas systems. Because of the potential hazard, it is important that existing facilities meet STORAGE, ventilation, handling, and operator training requirements if use is to continue. If these requirements are not met, use must be discontinued and a properly designed/sized and approved disinfectant system installed.

The following design criteria from an existing health code provide additional details for consideration when evaluating acceptability of an existing compressed gas installation.

- **Location.** The chlorinator room shall be located on the opposite side of the POOL from the direction of the prevailing winds. CHLORINE STORAGE and chlorinating equipment shall be in a separate room. This room shall be at or above grade.
- **Venting.** The CHLORINE room shall have a ventilating fan with an airtight duct beginning near the floor and terminating at a safe point of discharge to the out-of-doors. A louvered air intake shall be provided near the ceiling. The ventilating fan shall provide one air change per minute and operate from a switch located outside the door.
- **Door.** The door of the chlorinator room shall not open to the swimming POOL, and shall open outward directly to the exterior of the building. The door shall be provided with a shatterproof inspection window and should be provided with “panic hardware.”
- **Chlorine cylinders.** CHLORINE cylinders shall be anchored. The cylinders in use shall stand on a scale capable of indicating gross weight with one-half pound accuracy. STORAGE space shall be provided so that CHLORINE cylinders are not subjected to direct sunlight. STORAGE space shall be in an area inaccessible to the general public.
- **Injection location.** Mixing of CHLORINE gas and water shall occur in the CHLORINE room, except where vacuum-type chlorinators are used.
- **Backflow.** The chlorinators shall be designed to prevent the BACKFLOW of water or moisture into the CHLORINE gas cylinder

5.7.3.1.5 Salt Electrolytic CHLORINE Generators, Brine Electrolytic CHLORINE or Bromine Generators

R&F

In-line generators shall use only POOL-grade salt dosed into the POOL to introduce CHLORINE into the POOL vessel through an electrolytic chamber. -- Potential health risks associated with DISINFECTION byproducts forming from salt impurities, including bromide and iodide. For example, Kristensen et al. directly correlated bursts of bromodichloro-

methane formation to salt addition to POOL water over a MONITORING period of more than one year.³⁵¹ In a comparison study of common disinfectant methods, Lee et al. found salt brine electrolysis formed the highest levels of bromodichloro-methane, dibromochloro-methane and bromoform.³⁵² Zwiener et al. note that iodized table salt should not be used in salt POOLS because iodized DISINFECTION byproducts, which are generally more toxic than chlorinated DISINFECTION byproducts, could form.³⁵³ Additionally, there is a perception by some (see About.com reference) that salt water POOLS can be operated with table salt (which is commonly iodized).

5.7.3.2 Secondary or Supplemental Treatment Systems DWQ

Due to the risk of outbreaks of recreational water illnesses (RWIs) associated with halogen-tolerant pathogens such as *Cryptosporidium*, it is strongly recommended that all AQUATIC FACILITIES include SECONDARY DISINFECTION SYSTEMS to minimize the risk to the public associated with these outbreaks.

All existing regulations covering fecal events or detection of pathogens must still be adhered to when SECONDARY DISINFECTION SYSTEMS are utilized. SECONDARY DISINFECTION SYSTEMS can only minimize the risk and are not a guarantee of treatment due to the possibility of cross contamination of the POOL or water feature and the time required to pass the entire volume of water through the treatment process.

As the general effectiveness of a SECONDARY DISINFECTION SYSTEM is affected by the POOL or water feature TURNOVER rate and mixing/circulation within the POOL or water feature, the MAHC requirements for filter recirculation and TURNOVER rates must be followed. The performance of SECONDARY DISINFECTION SYSTEMS will be enhanced when the shortest TURNOVER times are achieved for any particular type of AQUATIC FACILITY.

The use of certain types of facilities presents a higher risk of recreational water illness (RWI) to users. These facilities include THERAPY POOLS, WADING POOLS, swim schools, and aquatic play facilities / features (SPRAY PADS), and aquatic play facilities / features. Given that users of these types of facilities frequently have lesser-developed immune systems (children), and / or a higher prevalence of disease (children and older adults), and / or compromised immune systems, and / or open wounds, additional precautions against RWIs are warranted.

CDC swimming POOL surveillance reports shows that of the 21,500 inspections conducted between May and September of 2002, water chemistry violations were found

³⁵¹ Kristensen GH, Klausen MM, Hansen VA, Lauritsen FR. On-line monitoring of the dynamics of trihalomethane concentrations in a warm public swimming pool using an unsupervised membrane inlet mass spectrometry system with off-site real-time surveillance. Rapid Commun Mass Spectrom. 2010 Jan;24(1):30-4.

³⁵² Lee J, Ha KT, Zoh KD. Characteristics of trihalomethane (THM) production and associated health risk assessment in swimming pool waters treated with different disinfection methods. Sci Total Environ. 2009 Mar 1;407(6):1990-7.

³⁵³ Zwiener C, Richardson SD, DeMarini DM, Grummt T, Glauner T, Frimmel FH. Drowning in disinfection byproducts? Assessing swimming pool water. Environ Sci Technol. 2007 Jan 15;41(2):363-72.

at 38.7% of these facilities. Of this percentage, 14.3% of the violations were for inadequate DISINFECTION levels at THERAPY POOLS³⁵⁴.

The use of INTERACTIVE WATER AQUATIC VENUES has previously been associated with outbreaks of gastroenteritis. In 1999, an estimated 2,100 people became ill with *Shigella sonnei* and / or *Cryptosporidium parvum* infections after playing at an "interactive" water fountain at a beachside park in Florida³⁵⁵.

In one of the largest outbreaks reported, approximately 2,300 persons developed cryptosporidiosis following exposure to a New York spray park. The environmental investigation revealed that filtration and DISINFECTION of the recycled water sufficient to protect the PATRONS from this disease. In response, emergency legislation was passed, which required the installation of SECONDARY DISINFECTION (e.g., ultraviolet radiation or ozonation) on water returning through the sprayers)³⁵⁶.

5.7.3.2.1 Ultraviolet Light DWQ

5.7.3.2.1.2 3-log Inactivation DWQ

Records of the correct calibration, maintenance and operation of SECONDARY DISINFECTION SYSTEMS should be maintained by the facility's management.

5.7.3.2.2 Ozone DWQ

5.7.3.2.3 Copper / Silver Ions DWQ

EPA has set current drinking water STANDARDS at 1.3 ppm for copper and 0.10 ppm for silver, which are generally accepted in the states that have requirements for this treatment. These ion generation systems are not meant to replace disinfecting halogen and the minimum levels must continue to be provided.

The manufacturer's recommended procedures should be followed to avoid the potential of staining, and operating the POOL with copper levels outside the recommended range may cause staining. Copper based algaecides should not be used in these systems since use of these products increase the level of copper in the POOL and increases the potential to cause health effects or stain surfaces.

In addition, studies have shown that the presence of copper in POOL water has a catalytic effect on the formation of TRIHALOMETHANES³⁵⁷.

³⁵⁴ Centers for Disease Control and Prevention (CDC). Surveillance data from swimming pool inspections--selected states and counties, United States, May--September 2002. MMWR Morb Mortal Wkly Rep. 2003 Jun 6;52(22):513-6.

³⁵⁵ Centers for Disease Control and Prevention (CDC). Outbreak of gastroenteritis associated with an interactive water fountain at a beachside park--Florida, 1999. MMWR Morb Mortal Wkly Rep. 2000 Jun 30;49(25):565-8.

³⁵⁶ Yoder JS et al; Centers for Disease Control and Prevention (CDC). Surveillance for waterborne disease and outbreaks associated with recreational water use and other AQUATIC FACILITY-associated health events--United States, 2005-2006. MMWR Surveill Summ. 2008 Sep 12;57(9):1-29.

³⁵⁷ Blatchley ER et al. Copper catalysis in chloroform formation during water chlorination. Wat Res 2003;37:4385-4394.

5.7.3.3 Other Sanitizers, Disinfectants, or Chemicals**DWQ**

The MAHC has opted to not include lists of disinfectants that should not be used in AQUATIC VENUES vs. just saying that they must not pose a hazardous issue with the CHLORINE or bromine disinfectants in use and that all water quality criteria must be met.

PHMB DWQ Polyhexamethylene biguanide hydrochloride (PHMB) is a polymeric antimicrobial that has been used as an alternative to CHLORINE and bromine. PHMB is often referred to as biguanide in the industry. The formal name for PHMB on US EPA accepted labels is “Poly (iminoimidocarbonyliminoimido-carbonyl iminohexamethylene) hydrochloride”. The US EPA REGISTERED PHMB for use in POOLS and SPAS as a “SANITIZER”. The EPA accepted label directions require that the concentration be maintained between 30 and 50 PPM (MG/L) as product (6 to 10 PPM (MG/L) of active ingredient).

PHMB is not an oxidizer and must be used in conjunction with a separately added product. Hydrogen peroxide is the strongly preferred oxidizer.

The vast majority of the PHMB used in POOLS and SPAS is in private residences but a limited number of public facilities have used PHMB.

Because of its limited use in public facilities there are few independent studies on the efficacy of PHMB in recreational water. Studies report that the rate of kill of bacteria is slower than that of CHLORINE under laboratory conditions. However, the US EPA found that manufacturer’s generated data demonstrated adequate efficacy under the EPA guideline DIS/TSS-12 to grant registration under the Federal Fungicide, Insecticide and Rodenticide Act (FIFRA) and without regard to whether the facility is public, semi-public or private. As part of their registration process the US EPA does not distinguish between public and private facilities. The efficacy data analyzed by the US EPA is company confidential and has not been reviewed as part of the development of the MAHC.

There are no known published studies of the efficacy of PHMB against non-bacterial POOL and SPA infectious agents (e.g. norovirus, hepatitis A, *Giardia sp.*, *Cryptosporidium spp.*), under use conditions. PHMB is generally compatible with both UV and ozone, but both UV and ozone will increase the rate of loss of PHMB. Since SECONDARY DISINFECTION SYSTEMS require the use of a halogen as the primary disinfectant, the use of PHMB, even with a secondary system is problematic.

PHMB IS NOT compatible with CHLORINE or bromine. POOLS using PHMB have a serious treatment dilemma for control of *Cryptosporidium* after a suspected outbreak, or even a diarrheal fecal accident. The addition of a 3 PPM (MG/L) of CHLORINE to a properly maintained PHMB-treated POOL results in the precipitation of the PHMB as a sticky mass on the POOL surfaces and in the filter. Removal of the precipitated material can be labor intensive.

Testing for PHMB requires special test kits. Conventional kits for halogens are not suitable. PHMB test kits are readily available at most specialty retail POOL stores and on-line.

Hydrogen Peroxide

DWQ

Hydrogen peroxide is not registered by the US EPA as a disinfectant for recreational water. Since it is not registered, the use of hydrogen peroxide as a recreational water disinfectant, or any market claims that implies hydrogen peroxide provides any biological control in recreational water is a violation of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Hydrogen peroxide has been granted registration by the US EPA as a hard surface disinfectant and several other applications. The US EPA Registration Eligibility Document (RED) on hydrogen peroxide is available from the EPA website at www.epa.gov/oppsrrd1/REDs/old_reds/peroxy_compounds.pdf. The US EPA posts PDF copies of accepted product labels on the National Pesticide Information Retrieval System website <http://ppis.ceris.purdue.edu/#>. Product claims for uses and concentration may be verified by reading the PDF of the US EPA stamped and accepted copy of the product use directions at this website.

When used as a hard surface disinfectant hydrogen peroxide is normally used at around 3%. When used in recreational water, hydrogen peroxide is used at 27 to 100 PPM (MG/L), which is 1111 and 300 times, respectively, more dilute than that used on hard surfaces. Borgmann-Strahsen evaluated the antimicrobial properties of hydrogen peroxide at 80 and 150 PPM (MG/L) in simulated POOL conditions.³⁵⁸ Whether 150 PPM (MG/L) of hydrogen peroxide was used by itself or in combination with 24 ppb of silver nitrate it had negligible killing power against *Pseudomonas aeruginosa*, *E. coli*, *Staphylococcus aureus*, *Legionella pneumophila* or *Candida albicans*, even with a 30 minute contact period. In the same tests the sodium hypochlorite controls displayed typical kill patterns widely reported in literature. Borgmann-Strahsen concluded that hydrogen peroxide, with or without the addition of silver ions, was, “no real alternative to CHLORINE-based DISINFECTION of swimming POOL water from the microbiological point of view.”

5.7.3.3.1 Chlorine Dioxide

DWQ

CHLORINE dioxide is not presently registered by the US EPA for any use in recreational water. Since it is not registered, the use of CHLORINE dioxide as an antimicrobial treatment (e.g. disinfectant, SANITIZER, algacide, slimicide, biofilm control agent) in recreational water, or any market claims that implies CHLORINE dioxide provides any biological control in recreational water is a violation of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). CHLORINE dioxide has been granted registration by the US EPA as an antimicrobial for other applications, including drinking water. One product was previously registered as a slimicide for use in PHMB-SANITIZED recreational water but that registration has since been dropped. The US EPA

³⁵⁸ Borgmann-Strahsen, R. Comparative assessment of different biocides in swimming pool water, International Biodeterioration and Biodegradation 2003;51:291-297.

Registration Eligibility Document (RED) on CHLORINE dioxide is available from the US EPA website at http://www.epa.gov/oppsrrd1/REDs/CHLORINE_dioxide_red.pdf.

CHLORINE dioxide has the potential to be an alternative remediation tool, but it has not yet been approved by EPA for this use and can be hazardous unless appropriate SAFETY protocols are included. CDC will evaluate further recommendations once more data are available.

The US EPA posts PDF copies of accepted product labels on the National Pesticide Information Retrieval System website <http://ppis.ceris.purdue.edu/#>. Product claims for uses and concentration may be verified by reading the PDF of the US EPA stamped and accepted copy of the product use directions at this website.

Potential for Using Chlorine Dioxide in the Future

DWQ

During the drafting of this section of the MAHC several members of the committee had interest in using CHLORINE dioxide as a remedial treatment for *Cryptosporidium* and *Legionella*. Recommendations for this were not pursued because of the status of CHLORINE dioxide under FIFRA. Published studies, including the EPA Alternate DISINFECTION Manual for drinking water show that CHLORINE dioxide may be a very rapid remedial treatment for these life-threatening pathogens. If the registration status of CHLORINE dioxide changes the writing committee suggests that CHLORINE dioxide use should be reconsidered.

Provisions for Emergency Use of Chlorine Dioxide

DWQ

Even though CHLORINE dioxide is not presently registered for use in recreational water, it is possible to use it under Section 18 of FIFRA. An example of this would be the remediation of a *Legionella*-contaminated health club SPA where other treatments were proven to be ineffective. More information on emergency exemptions can be found on the US EPA website at <http://www.epa.gov/opprd001/section18/>. Because of the lack of existing use directions and potential for occupational exposure, it is strongly suggested that a certified industrial hygienist be included in developing emergency treatment plans.

5.7.3.3.2 Other Aquatic Venue Water Treatment Products

DWQ

Clarifiers, Flocculants, and Defoamers

DWQ

POOLS and SPAS may benefit from the use of one or more of these types of products periodically. There are numerous brands available that are formulated for commercial POOLS and SPAS. Each product is marketed for a specific procedure. Each may contain one or more natural or synthetic polymers, chemical or metallic ingredients. Neither the efficacy nor the SAFETY of product chemistry of these products has been reviewed by the US EPA or any other federal agency. The state of California does require submission of a detailed data package prior to registration. Products sold in the state of California must have the state registration number on the label. Products registered in California but sold outside of the state usually, but are not required to, have the California registration number on the label. Any local agency concerned about a

particular product could request the producer supply the California registration number and then verify the status of the product with the California Department of Pesticide Regulation.

5.7.3.4 pH

DWQ

There are three reasons to maintain pH:

- efficacy of the CHLORINE,
- BATHER comfort, and
- maintenance of balanced water.

Each of these reasons are discussed briefly below. The efficacy of CHLORINE/hypochlorous acid is dramatically impacted by pH and therefore pathogen inactivation can be severely affected by higher pH levels where only a small percentage of free CHLORINE is active. Lower pH levels below this range allow a greater percentage of free CHLORINE to be “active”. Further data are needed to ensure that lower levels (e.g., 6.8 to 7.2) do not adversely impact membranes, particularly eyes. The present practice of maintaining the pH between 7.2 and 7.8 has been developed by coupling physical chemistry with empirical observations. There is no definitive peer-reviewed study that extensively covers the subject of pH in POOL and SPA water except those showing the titration of hypochlorous acid and the importance of pH for assuring maximal efficiency. The best general authority is the 1972 edition of the Handbook of Chlorination by Geo. Clifford White. The 1972 edition of this widely recognized authority on CHLORINE chemistry is the only edition that has a chapter especially on POOLS. Much, but not all, of the POOL chemistry chapter can be found in subsequent editions. Copies of the 1972 edition are difficult to locate in libraries but are available for sale on the internet as of July 2009. The discussion on efficacy and BATHER comfort is a summary of the 1972 edition discussion on pH.

Efficacy of Chlorine

DWQ

CHLORINE used in POOLS refers to hypochlorous acid. Hypochlorous acid (HOCl) is a weak acid that readily dissociates to form hypochlorite (OCl⁻) and hydrogen ion (H⁺). The mid-point of the dissociation (the pK_a) is at pH 7.5. Functionally, this means that at pH of 7.5, 50% (fifty percent) of the free CHLORINE present will be in the form of hypochlorous acid and 50% (fifty percent) will be in the form of hypochlorite. As the pH decreases below 7.5, the proportion of hypochlorous acid increases and proportion of hypochlorite ion decreases. The opposite occurs as the pH increases above 7.5. Numerous investigators have reported that hypochlorous acid is approximately 100 times more effective at killing microorganisms than the hypochlorite ion. Thus, from a public health perspective it is desirable to maintain the pH so as to maximize the portion of hypochlorous acid portion of the free CHLORINE present in the water.

Bather Comfort

DWQ

As BATHERS enter the water their skin and eyes come into direct contact with the water and its constituent components. In general the eyes of BATHERS are more sensitive to irritation than the skin. Studies on the sensitivity of BATHER’s eyes to pH changes of the

water show wide variations in tolerance limits. The tolerance of the eye to shifts in pH is also impacted by the concentration of free CHLORINE, combined CHLORINE, and alkalinity. Under normal POOL conditions the optimum limits for BATHER comfort appears to be from pH 7.5 to 8.0.

Potential for Lowering pH in the Future

DWQ

During the review of the data the MAHC committee had a broad interest in lowering the minimum pH. This would increase the efficacy of the CHLORINE by increasing the proportion of hypochlorous acid (at the expense of hypochlorite) and thus increase DISINFECTION efficacy. This was not recommended because of the lack of data on the impact on BATHERS, particularly the eyes. If additional information on the impact of lower pH on BATHERS' skin and eyes is developed, the MAHC committee suggests that the acceptable range for pH be reexamined. As part of the reexamination, consideration should also be made concerning how this change will impact the water balance and any possible negative impact on the facility.

5.7.3.5 Feed Equipment

5.7.3.5.7 Gas Feed Systems

R&F

The Chlorine Institute has checklists and guidance at <http://chlorineinstitute.org/stewardship/ci-checklists.cfm> for working with compressed CHLORINE gas.

5.7.3.6 Testing for Water Quality and Circulation

M&T

When collecting samples from POOLS, an 18-inch (45.7 cm) water depth for sample collection is recommended. Both the National Swimming Pool Foundation (NSPF) Certified Pool Operator manual and the National Recreation and Park Association (NRPA) AQUATIC FACILITY Operator manual instruct the operator to reach at least 18 inches (45.7 cm) below the water's surface to collect the water sample. In an outdoor POOL, there is chemical interaction with ultraviolet light at the surface which will affect the reading. Most of the chemical CONTAMINANTS in a POOL are located within the top 18 inches, which is why most studies of POOL CONTAMINANTS are performed by collecting samples at a depth of ≤ 30 cm (11.8 inches) below the POOL water surface^{359,360}. These CONTAMINANTS will give false pH and SANITIZER readings in indoor and outdoor POOLS. To sample, plunge the assembly (mouth first) quickly to the marked depth, invert, and let the bottle fill. Remove when full of water, begin testing.

5.7.3.7 Automated Controllers

5.7.3.8 Microbiological Testing Equipment

5.7.3.9 Filtration and Water Treatment Equipment

³⁵⁹ De Laat et al. (2011) Concentration levels of urea in swimming pool water and reactivity of chlorine with urea. *Water Research*, 45(3):1139-1146.

³⁶⁰ Weaver et al. (2009) Volatile disinfection by-product analysis from chlorinated indoor swimming pools. *Water Research*, 43(13):3308-3318.

Water Sample Collection and Testing

5.7.4.1 Sample Collection

5.7.4.2 Routine Samples

5.7.4.3 Bulk Water Sample

5.7.4.3.3 Aquatic Venue Water Chemical Balance

Water Balance

DWQ

Water balance is a term used to describe the tendency of water to dissolve (corrode) or deposit minerals (form scale) on surfaces contacted by the water. Balanced water will neither corrode surfaces nor form scale. Factors that impact water balance are pH, hardness, alkalinity, dissolved solids, and temperature. The presently used water balance parameters are used to protect POOL equipment and surfaces from deleterious effects of corrosion and scale formation. Improperly balanced water is not in itself a threat to public health. Water balance is expressed in several ways but the most common one is by the SATURATION INDEX. Each factor in the SATURATION INDEX equation can vary within a limited range and the water is still considered balanced. Shifts in pH have a significant impact on water balance. Water balance chemistry is discussed extensively in all POOL operator classes and is well beyond the scope of this Annex.

5.7.4.3.3.1 Total Alkalinity Level

DWQ

Total alkalinity is closely associated with pH, but rather than a measure of hydrogen ion concentration, it is a measure of the ability of a solution to neutralize (buffer) hydrogen ions. Expressed in parts per million (PPM), total alkalinity is the result of alkaline materials including carbonates, bicarbonates and hydroxides - mostly bicarbonates. As noted in the CODE, the ideal range is 60 PPM to 180 PPM. This acid neutralizing (buffering) capacity of water is desirable because it helps prevent wide variations in pH (pH bounce) whenever small amounts of acid or alkali are added to the POOL. Total alkalinity is a measure of water's resistance to change in pH and is a source of rising pH itself from the outgassing of carbon dioxide.

Too Low

DWQ

If total alkalinity is too low: pH changes rapidly when chemicals or impurities enter the water. pH may drop rapidly when using net acidic sources of CHLORINE or other acidic chemicals (e.g. Trichlor (trichloro-s-triazinetrione), Dichlor (sodium dichloro-s-triazinetrione), potassium monopersulfate), causing etching and corrosion.

Raising Total Alkalinity

Total alkalinity can be raised by the addition of bicarbonate of soda (sodium bicarbonate, baking soda). 1.4 lbs. bicarbonate of soda per 10,000 gallons will raise total alkalinity ~10 PPM.

Too High

DWQ

If total alkalinity is too high: pH becomes difficult to adjust. High pH often occurs causing other problems such as; cloudy water, decreased disinfectant effectiveness, scale formation and filter problems. The higher the total alkalinity, the more resistant the water is to large changes in pH in response to changes in the dosage of disinfectant and pH correction chemicals. If the total alkalinity is too high, it can make pH adjustment difficult.

Lower Total Alkalinity

Add acid - The acid reacts with bicarbonates in the water and reduces the total alkalinity. Add 1.6 pounds of Dry Acid (Sodium Bisulfate) per 10,000 gallons of water, or 1.3 quarts of Muriatic Acid, to decrease the Total Alkalinity by 10 PPM. Retest and adjust the pH.

High levels of cyanuric acid will cause interference in the total alkalinity test. This interference is magnified at low levels of total alkalinity. To correct for cyanuric acid interference, measure the concentration of cyanuric acid, divide that number by 3, and then subtract that value from the measured total alkalinity value.

Minor deviations from the alkalinity levels stated in the CODE do not in themselves present imminent health threats to the BATHERS. As such, minor deviations in alkalinity levels do not require the immediate closure of the facility. Rather, deviations from permissible alkalinity levels indicate poor management of the water balance and should indicate a need for a thorough inspection of the entire facility.

5.7.4.3.3.2 Combined Chlorine (Chloramines) DWQ

Combined CHLORINE compounds (chloramines) are formed when FREE AVAILABLE CHLORINE combines with amine-containing compounds such as urea, amino acids, and ammonia from perspiration and urine. Chloramines include inorganic compounds (monochloramine (NH_2Cl), DICHLORAMINE (NHCl_2) and TRICHLORAMINE (NCl_3)) as well as a variety of organic compounds. Inorganic chloramines are biocides, but are much less effective as quick kill disinfectants than FREE AVAILABLE CHLORINE. If the local water treatment plant uses chloramination for drinking water DISINFECTION, inorganic chloramines (predominantly monochloramine) may be present in the fill water.

High Chloramines DWQ

A high level of chloramines is undesirable in POOLS and SPAS. The maximum level for combined CHLORINE is 0.4 PPM (MG/L). Higher levels indicate that bathing loads or pollution from BATHERS may be too high, or that treatment is inadequate. Higher levels may also pose a health concern to BATHERS, employees, and other POOL attendees.

The World Health Organization recommends that combined CHLORINE levels be “as low as possible, ideally below 0.2 MG/L”³⁶¹. However, this “ideal” level would be challenging to implement as a CODE requirement.

³⁶¹ WHO. Guidelines for safe recreational water environments. Volume 2, Swimming pools and similar environments. 2006: 71. Accessed at: http://www.who.int/water_sanitation_health/bathing/srwe2full.pdf.

Published data are limited, but suggest that combined CHLORINE levels are commonly above 0.2 PPM (MG/L) in swimming POOL water^{362, 363, 364}.

Inorganic Chloramines

DWQ

Volatilization of chloramine compounds can lead to strong objectionable odors in POOL environments, as well as eye, mucous membrane, and skin irritation for BATHERS and attendants. Among the inorganic chloramines, NCl_3 has the greatest impact on air quality, owing to its relatively low affinity for water and its irritant properties. NCl_3 has been reported to be an irritant at concentrations in water as low as 0.02 PPM (MG/L).

Odors are unlikely to be present from organic chloramines below the following concentrations:

- Monochloramine (NH_2Cl): 5.0 PPM (MG/L)
- DICHLORAMINE (NHCl_2): 0.8 PPM (MG/L)
- Nitrogen trichloride (NCl_3): 0.02 PPM (MG/L)

Research to understand the relationship between inorganic chloramine concentrations in water and their impact on air quality is limited, although some research indicates that the gas phase NCl_3 concentration is dynamic and impacted by BATHER LOAD, swimmer activity, liquid phase NCl_3 concentration. Reliable sampling and analytical methods affect the accuracy of the characterization of the POOL water and air.

Health Incidents

DWQ

Studies of swimming POOL users and non-swimming attendants have shown a number of changes and symptoms that appear to be associated with exposure to the atmosphere in swimming POOLS. CDC has intervened and investigated various health incidents reporting skin and eye irritation and acute respiratory outbreaks that could be associated with exposures to chloramines and other by-products at recreational water facilities, including swimming POOLS^{365,366}.

Lifeguard Exposure DWQ

For lifeguards at swimming POOLS, an exposure–response relationship has been identified between NCl_3 , measured as total chloramines, and irritant eye, nasal, and

³⁶² Weaver WA et al. Volatile disinfection by-product analysis from chlorinated indoor swimming POOLS. Water Res. 2009 Jul;43(13):3308-18.

³⁶³ Lahl U et al. Distribution and balance of volatile halogenated hydrocarbons in the water and air of covered swimming pools using chlorine for water disinfection. Water Res. 1981;15:803-814.

³⁶⁴ Lévesque B et al. The determinants of prevalence of health complaints among young competitive swimmers. Int Arch Occup Environ Health. 2006 Oct;80(1):32-9.

³⁶⁵ Dziuban EJ et al. Surveillance for waterborne disease and outbreaks associated with recreational water--United States, 2003-2004. MMWR Surveill Summ. 2006 Dec 22;55(12):1-30.

³⁶⁶ Centers for Disease Control and Prevention (CDC). Ocular and respiratory illness associated with an indoor swimming pool--Nebraska, 2006. MMWR Morb Mortal Wkly Rep. 2007 Sep 14;56(36):929-32.

throat symptoms, although not chronic respiratory symptoms or bronchial hyper responsiveness.³⁶⁷

Respiratory Conditions

DWQ

In addition to potential occupational exposures, there have been a number of studies investigating respiratory conditions, including asthma, related to swimming POOLS.

There appears to be no consistent association between swimming POOL attendance during childhood and the prevalence of asthma or atopic disease^{368, 369, 370}. Studies indicate that asthma is more commonly found among elite swimmers than among other high-level athletes, although it is premature to draw conclusions about the causal link between swimming and asthma because most studies available to date used cross-sectional design, because the association is not confirmed among non-competitive swimmers, and because asthmatics may be more likely to select swimming as the activity of choice because of their condition.³⁷¹

Contact Dermatitis DWQ

Chloramines have also been implicated in contact dermatitis (rashes). The number of rashes that occurs among BATHERS in treated recreational water is not known. One cross-sectional study of Australian school POOLS retrospectively examined the incidence rate of rashes in three POOLS. The three POOLS treatment types were CHLORINE alone (hand dosing), CHLORINE plus ozone (automatic dosing and control), and bromine (sodium bromide plus ozone using automatic dosing and control). This study reported 14.4% of the BATHERS in the hand-dosed CHLORINE POOLS experienced rashes.³⁷² This and anecdotal reports strongly suggests that rashes are the most common RWI. The greatest number of rashes appears to be among hydro-therapists (aquatic physical therapists). A survey of 190 professional hydro-therapists in Israel reported that 45% developed skin disease after beginning work. Symptoms reported included itchiness, redness, dry skin. The areas affected were the extremities, the face and trunk, and folds in the skin. The authors concluded: 1) exposure to water influences development of irritant contact dermatitis; 2) cumulative exposure of low-potency irritants may be cause of contact dermatitis; 3) contact dermatitis is an occupational disease of hydro-therapists.³⁷³ In these and similar reports the exact chemical species inducing the contact dermatitis has not been identified but the collective opinions of the investigators is that halogenated organic compounds (DISINFECTION BY-PRODUCTS) is the cause. One conservative estimate places the number of halogenated DISINFECTION byproducts, including organic chloramines, in swimming POOLS at greater than 200. The clinical

³⁶⁷ Massin N et al. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming POOLS. *Occup Environ Med.* 1998 Apr;55(4):258-63.

³⁶⁸ Goodman M et al. Asthma and swimming: a meta-analysis. *J Asthma.* 2008 Oct;45(8):639-47.

³⁶⁹ Schoefer Y et al. Health risks of early swimming pool attendance. *Int J Hyg Environ Health.* 2008;211(3-4):367-73.

³⁷⁰ Weisel CP et al. Childhood asthma and environmental exposures at swimming POOLS: state of the science and research recommendations. *Environ Health Perspect.* 2009 Apr;117(4):500-7.

³⁷¹ Schoefer Y et al. Health risks of early swimming pool attendance. *Int J Hyg Environ Health.* 2008;211(3-4):367-73.

³⁷² Fitzgerald DA et al. Spa pool dermatitis. *Contact Dermatitis.* 1995 Jul;33(1):53.

³⁷³ Rycroft RJ et al. Dermatoses associated with brominated swimming pools. *Br Med J (Clin Res Ed).* 1983 Aug 13;287(6390):462.

significance of these is likely to vary with the concentration of specific chloramine and BATHER specific factors (length of exposure, underlying health conditions, and cumulative previous exposure).

Maximum Concentration

DWQ

After considerable discussion the MAHC committee decided to recommend a maximum concentration of 0.4 PPM (MG/L) for combined CHLORINE in all recreational waters. This recommendation is based on the desire to minimize the potential for both respiratory and dermal disease that is known to be associated with exposure to chloramines. The committee recognizes that this concentration is arbitrary and that it is has not been substantiated by adequate human clinical studies. In the absence of an adequate human study the committee has opted for a conservative value rather than a more lenient value of 0.5 PPM (MG/L) preferred by some operators. The key is that regulators start enforcing regular testing for combined CHLORINE so that POOL operators work towards keeping levels low.

Levels of chloramines and other volatile compounds in water can be minimized by reducing introduction of CONTAMINANTS that lead to their formation (e.g., urea, creatinine, amino acids and personal care products), as well as by use of a shock oxidizer (e.g., potassium monopersulfate) or supplemental water treatment. Effective filtration, water replacement, and improved BATHER hygiene (e.g., showering, not urinating in the POOL) can reduce CONTAMINANTS and chloramine formation.

Shock dosing with CHLORINE can destroy inorganic chloramines that are formed. Some research shows that non-CHLORINE shock oxidizers reduce the propensity to develop chloramines. However, this research has not been peer-reviewed to date. The USEPA has determined that manufacturers of “shock oxidizers” may advertise that their “shock oxidizer” products “remove,” “reduce,” or “eliminate” organic CONTAMINANTS (http://www.epa.gov/oppad001/shock_ltr.htm).

Secondary Disinfection

DWQ

SECONDARY DISINFECTION SYSTEMS such as ozone and ultraviolet light may effectively destroy inorganic chloramines. As this also has a public benefit and can assist in meeting the MAHC requirements for combined CHLORINE, it is strongly recommended that any installation utilizing UV or ozone as a SECONDARY DISINFECTION SYSTEM consider the positive impact the equipment may have on reducing combined CHLORINE levels in addition to achieving DISINFECTION goals.

To improve chloramine control strategies, future research should be aimed at:

- defining the fundamental chemistry of DISINFECTION byproducts including, organic and non-organic chloramine formation from precursor compounds that are common to swimming POOLS,
- defining relationships between levels of combined CHLORINE in water and air of AQUATIC VENUES and the adverse effects on POOL attendees, to include inhalation, ingestion and contact,

- documenting efficacy of water treatment technologies to reduce chloramine levels,
- improve testing for combined CHLORINE in air and water, and
- testing for the components of combined CHLORINE.

5.7.4.3.3.3 Calcium Hardness

DWQ

Calcium hardness is the amount of dissolved calcium (plus some other minerals like magnesium) in the water. High calcium is not healthy for swimming since it can cause burning of the mucous membranes, as well as skin irritation on sensitive people. Calcium hardness of 200 - 400 PPM (MG/L) is preferred for proper calcium carbonate saturation and for avoiding soft-water scale found in SPAS and hot tubs when other water parameters are near their nominal levels. For venues with water temperature greater than 90 degrees F, the range should be 100 to 400 PPM.

Too much calcium causes cloudiness and scale formation. It also reduces the effectiveness of disinfectants. Too little calcium, especially when combined with low pH or low Total Alkalinity can also lead to “aggressive water,” which can dissolve calcium carbonate from plaster, as well as metallic parts of the POOL (walls, floor, hand rails, ladders, light fixtures, and equipment), and also cause discolored water or stains on the POOL walls and floor.

The maximum permissible concentration of 400 PPM (MG/L) may not be appropriate for regions with particularly hard source water. In such regions local CODES should reflect the specialized practices needed for source waters containing >400 PPM (MG/L) total hardness.

Minor deviations from the calcium hardness levels stated in the CODE do not in themselves present imminent health threats to the BATHERS. As such, minor deviations in hardness levels do not require the immediate closure of the facility. Rather, deviations from permissible hardness levels indicate poor management of the water balance and should indicate a need for a thorough inspection of the entire facility.

5.7.4.3.3.4 Algaecides

DWQ

In practice most algaecides are reasonably effective when applied according their US EPA accepted label directions and the application is coupled with frequent and thorough brushing.

CHLORINE and bromine can be registered and used as algaecides, but must be used in accordance with EPA label directions.

Bromine and bromamine have been demonstrated to be algaecidal.³⁷⁴

Common Types DWQ

³⁷⁴ Kott Y et al. Algicidal effect of bromine and chlorine on *Chlorella pyrenoidosa*. Appl Microbiol. 1966 Jan;14(1):8-11.

The two basic types of non-halogen algaecides are copper based algaecides and quaternary ammonia compounds (QACs), often referred to as “quats”. Some algaecides contain a mixture of a quat and a copper compound.

Copper-based algaecides can be used to treat against all types of algae, but are especially effective against mustard and green types of algae. These will not cause foam to appear in a swimming POOL as is common with simple quaternary ammonia types of algaecides. There is however a problem with stains on the surface of the swimming POOL if the product is not used properly. Proper pH control is very important to minimize staining potential when using copper-containing algaecides.

The other most common types are quaternary ammonium. These algaecides will not stain a swimming POOL. There are two types of quats: simple and polymeric (more commonly called “polyquats”). Simple quats are mixtures of various alkyl dimethyl benzyl ammonium compounds (ADBACs) or didecyl dimethyl ammonium compounds (DDACs). There are numerous variations of these. The technical name for the active ingredient in polyquats is “Poly[oxyethylene (dimethylimino) ethylene (dimethylimino) ethylene dichloride]”. Neither type of quat will cause staining. When overdosed, simple quats tend to cause foam, especially in POOLS with water features (e.g. fountains, waterfalls). Polyquats do not cause foaming, even when used repeatedly at the maximum label dose in POOLS with water features.

EPA-Registered

DWQ

In selecting a quat, it is vital that the product has been registered by the US EPA for use in swimming POOLS. The vast majority, but not all, of the products on the market have current US EPA registrations. All products registered by the US EPA will have a registration number on the label (usually it will state “EPA Reg. No.” followed a series of numbers). This registration number can be verified by using the EPA National Pesticide Information Retrieval System (<http://ppis.ceris.purdue.edu/#>) which is managed for the EPA by Purdue University. As part of their registration process the US EPA does not distinguish between public and private facilities.

Registered Products DWQ

The US EPA registration process for algaecides is substantially different than the registration process used for disinfectants. As part of the development of the product, the US EPA requires companies to conduct efficacy studies on the product. The US EPA does not consider algae in POOLS or SPAS to be pathogenic and thus not a direct threat to public health. Since algae are not a public health issue, the US EPA does not require companies to submit their efficacy package for an agency data review. Thus, in the registration process the US EPA looks carefully at the toxicology of the product but not the efficacy. The state of California does require detailed efficacy studies prior to registration. Products sold in the state of California must have the state registration number on the label. Products registered in California but sold outside of the state usually, but are not required to, have the California registration number on the label. Any local agency concerned about the efficacy a particular algaecide could request the producer supply the California registration number and then verify the status of the product with the California Department of Pesticide Regulation.

“This information is distributed solely for the purpose of pre-dissemination public comment under applicable information quality guidelines. It has not been formally disseminated by the Centers for Disease Control and Prevention. It does not represent and should not be construed to represent any agency determination or policy.”

5.7.4.3.4 Source (fill) Water**DWQ**

Most public recreational water venues use the PUBLIC WATER SUPPLY as the fill water source. In instances where this is not possible, it is important that the fill water not be a potential source of illness to BATHERS. Since requirements governing water quality vary by jurisdiction, it is not possible to specify every test that might be required by a jurisdiction. Therefore, facilities need to insure that the fill water complies with the jurisdictional requirements. Examples of potential tests that a jurisdiction may require include, but are not limited to the following: bacteria, nitrates, nitrites, iron, manganese, sulfur, and turbidity. It is also recommended that this testing be conducted on an annual basis.

5.7.4.4 Saturation Index for Aquatic Venues**5.7.4.4.1 Water Balance Determination****DWQ**

Water balance is an important part of proper POOL and SPA operation and maintenance. As such, the Langelier SATURATION INDEX (LSI) is a useful tool for MONITORING the corrosive or scale-forming tendencies of POOL or SPA water. Although there is little scientific literature on the LSI and POOL / SPA water, it is common industry practice to use this index.

The LSI formula is: $LSI = pH + TF + CF + AF - TDSF$

- **pH** Obtained by testing the POOL or SPA water
- **TF** Temperature Factor - using the chart below, look up the actual POOL or SPA water temperature at the time of sampling, in order to obtain the appropriate TF value.
- **CF** Calcium Hardness Factor - determine the PPM (MG/L) of calcium hardness (CH) in the water sample. Using the chart below, use the appropriate calcium hardness (CH) reading, in order to obtain the appropriate CF value.
- **AF** Total Alkalinity Factor - determine the PPM (MG/L) of total alkalinity (TA) in the water sample. Using the chart below, use the appropriate total alkalinity (TA) reading, in order to obtain the appropriate AF value.
- **TDSF** Total Dissolved Solids Factor – If the TDS of the water is less than 1,000 PPM (MG/L), use the factor of 12.1. If the TDS of the water is greater than 1,000 PPM (MG/L), use the factor of 12.2.

Note: Use the TF, CF, and AF factors closest to your actual reading

Total Dissolved Solids**DWQ**

A generally accepted level for TDS in AQUATIC VENUES is 1,500 PPM (MG/L) above the TDS level in the fill water. For POOLS USING CHLORINE GENERATORS, startup TDS level should be measured on the initial fill after adding the salt for the CHLORINE generator. Additional research needs to be done to determine TDS in salt water POOLS, and its impact on water quality.

Total dissolved solids (TDS) are a measure of the overall quantity of matter in the POOL that is not water. This matter includes such things as minerals (calcium, magnesium, etc.), chemicals, body oils, sunscreen, etc. that are not removed by filtration.

There is only one state that has a maximum required TDS level (2,500 PPM (MG/L)). However, there is no known scientific data that substantiates any value as a maximum level. The 1,500 PPM (MG/L) level is utilized based on the fact that as the concentration of these materials increases in the POOL they can result in staining, cloudy water, decreased effectiveness of disinfectants (by up to 50%), and an enhanced environment for the growth of algae. Excessively high TDS levels (> 5000 PPM (MG/L)) may require more drastic measures such as a complete POOL drain and refill, or additional water filtering, as a complete water drain may damage some POOLS.

It is also important to note that the salt required by saltwater chlorination systems will substantially increase the TDS level. Therefore, in saltwater POOLS, it is best to consider the TDS level after the required amount of salt has been added to a freshly filled POOL as the baseline level.

5.7.4.4.2 Langelier Index Conversion Chart

DWQ

TF		CF		AF	
Temp°F / °C	TF	CH PPM (MG/L)	CF	TA PPM (MG/L)	AF
32°F / 0°C	0.0	5	0.3	5	0.7
37°F / 3°C	0.1	25	1.0	25	1.4
46°F / 8°C	0.2	50	1.3	50	1.7
53°F / 12°C	0.3	75	1.5	75	1.9
60°F / 16°C	0.4	100	1.6	100	2.0
66°F / 19°C	0.5	150	1.8	150	2.2
76°F / 24°C	0.6	200	1.9	200	2.3
84°F / 29°C	0.7	300	2.1	300	2.5
94°F / 34°C	0.8	400	2.2	400	2.6
105°F / 41°C	0.9	800	2.5	800	2.9
128°F / 53°C	1.0	1000	2.6	1000	3.0

Water balance should fall within the range of -0.3 to $+0.3$, as determined by the Langelier SATURATION INDEX.

A low Langelier Index (a value less than -0.3) can result in corrosion, BATHER irritation and discomfort. POOL water may cause etching, pitting, dissolving and staining of walls, grouting and plumbing.

- LSI Decreases as:
- Stabilizer Increases, and
- Total Dissolved Solids Increase.

A high Langelier Index (a value greater than $+0.3$) can lead to scale formation, cloudy water, filtration problems, heater problems, loss of CHLORINE efficiency and BATHER discomfort. POOL water may deposit excess minerals on the POOL and equipment. Scale generally appears as white or lightly colored rough blotches on the POOL walls. It also adheres to other objects in the POOL, piping and filter system. Scale can restrict water flow, shortening filter runs and reducing filtration efficiency.

LSI Increases as:

- Temperature Increases,
- Total Alkalinity Increases,
- pH Increases, LSI Increases, and
- Calcium Hardness Increases.

A small positive value is preferred over a negative value because a slight scale layer provides some protection, and is less harmful than corrosion, which causes permanent damage to mechanical and structural components.

Langelier Indexes can be adjusted to the -0.3 to $+0.3$ range by:

- Adjusting the pH to 7.2 to 7.6, and
- Adjusting the total alkalinity to 60 to 180 PPM (MG/L), and
- Adjusting the calcium hardness to 200 to 400 PPM (MG/L) for a masonry POOL or SPA or 80 to 200 PPM (MG/L) for a vinyl or fiberglass unit.

While it is always possible to lower the pH, it is not as simple with the total alkalinity or calcium hardness. Lowering the total alkalinity will usually lower the pH as well. Lowering the calcium hardness is not always possible, given the variation in hardness of the fill water. In situations where the calcium level is high, attention should be paid to lowering the pH and / or total alkalinity in order to improve the LSI.

It is not always possible to get the pH and total alkalinity within the proper range, due to the nature of the dissolved minerals. pH is the more important parameter, and should be maintained within the proper range.

If the POOL or SPA is outdoors, and uses stabilized CHLORINE, in order to get a more accurate reading of the LSI, it is recommended that 30% of the cyanuric acid reading be deducted from the total alkalinity test result.

Ryznar Stability Index

DWQ

The link for tables and references for Ryznar index is

<http://www.lenntech.com/calculators/ryznar/index/ryznar.htm>

The criteria used for an indication are as shown in Tables 4 and 5 below:

Table 4

RI	Indication (Ryznar 1942)
RI < 5,5	Heavy scale will form
5,5 < RI < 6,2	Scale will form
6,2 < RI < 6,8	No difficulties
6,8 < RI < 8,5	Water is aggressive
RI > 8,5	Water is very aggressive

RI	Indication (Carrier 1965)
4,0 - 5,0	Heavy scale
5,0 - 6,0	Light scale
6,0 - 7,0	Little scale or corrosion
7,0 - 7,5	Corrosion significant
7,5 - 9,0	Heavy corrosion
>9,0	Corrosion intolerable

Table 5

Read more:

<http://www.lenntech.com/calculators/ryznar/index/ryznar.htm#ixzz2Wmc9UOKg>

From 1988 NALCO Water Treatment Handbook; NALCO Water Company, Frank M. Kemmer, editor. McGraw Hill Book Publishers, page 4.

“As a general rule, the Langelier Index is most useful in bulk systems and the Ryznar Index in flowing systems where the velocity is greater than about 2 f/s, or sufficient to prevent sedimentation.”

Ryznar Stability Index (RSI)

DWQ

The Ryznar stability index (RSI) uses a database of scale thickness measurements in municipal water systems to predict the effect of water chemistry.

Ryznar SATURATION INDEX (RSI) was developed from empirical observations of corrosion rates and film formation in steel mains. It is defined as:

- $RSI = 2 \text{ pHs} - \text{pH (measured)}$
- For $6.5 < RSI < 7$ water is considered to be approximately at saturation equilibrium with calcium carbonate
- For $RSI > 8$ water is under saturated and, therefore, would tend to dissolve any existing solid CaCO_3
- For $RSI < 6.5$ water tends to be scale forming

5.7.4.5 Water Temperature

DWQ

Specialized populations may require specific water temperatures for safe and effective programming.

Some general guidelines are as follows:

- Cold water can affect both mental and bodily functions, possibly preventing clear thinking and restricting normal physical activity. It is uncomfortable and can be painful, and puts a strain on the body as you try to rewarm. By definition, water below 70°F (21°C) is considered cold, due to the fact that body heat is absorbed twenty-five times faster in water than air."
- Specialized populations may require specific water temperatures for safe and effective programming. Some general guidelines are provided here and additional information is included in the annex. Multi use AQUATIC VENUES are usually kept at $83^\circ\text{F} - 86^\circ\text{F}$ ($28^\circ\text{C} - 30^\circ\text{C}$), while competitive AQUATIC VENUES are usually maintained at cooler temperatures between $78^\circ\text{F} - 82^\circ\text{F}$ ($25.5^\circ\text{C} - 27.5^\circ\text{C}$). Depending on the target population, instructional and THERAPY POOL water temperatures usually range between $86^\circ\text{F} - 94^\circ\text{F}$ ($30^\circ\text{C} - 34^\circ\text{C}$).

The following table from USA Swimming provides guidelines for water temperatures based on activity and population:

Bather Type	Temperature Range	Notes
Swim Team & Lap Swim	78°-82° F (25.5°-27.5°C)	Slightly warmer may be workable
Resistance Training	83°-86°F (28°-30° C)	---
Therapy & Rehab	91°-95°F (33°-35°C)	Can be as low as 87 F for many types of therapy
Multiple Sclerosis	80°-84°F (26.5°-29°C)	Warmer water can cause adverse effects
Pregnancy	78°-84°F (25.5°-29°C)	Warmer water can cause adverse effects
Arthritis	84°-90°F (29°-31°C)	Arthritis Foundation min/max
Arthritis	86°-90°F (28°-32°C)	ATRI low function program
Fibromyalgia	86°-96°F (30°-35.5°C)	ATRI
Aerobic activity	84°-88°F (29°-31°C)	---
Older adults – vertical	83°-86°F (28°-30°C)	Moderate to high intensity
Older adults – vertical	86°-88°F (30°-31°C)	Low intensity
Children, fitness	83°-86°F (28°-30°C)	---
Children's swim lessons	82° F (27.5°C)	Varies with age and class length
Obese	80°-86° F (26.5°-30°C)	---

There are no definitive temperatures that are applicable for all uses of an AQUATIC VENUE. The suggested POOL water temperature is dependent on the person's activity in the POOL. For example, individuals participating in competitive swimming prefer cooler water (70-80° F) than individuals participating in water fitness for arthritis (83° F minimum) (http://www.uswfa.com/suggested_POOL_temps.asp). Water ranging in temperature from 79-86° F is comfortable for most swimmers throughout prolonged periods of moderate physical exertion.⁶³

However, there are maximum temperatures that can and do have an effect on the health of the PATRON using the facility. Water temperature between 83-86° F is the most comfortable temperature for typical recreational water usage. Water temperature may need to be adjusted based upon specific uses of the facility.

The WHO recommends that water temperatures in hot tubs be kept below 104° F. High temperatures (above 104° F) in SPAS or hot tubs can cause drowsiness, which may lead to unconsciousness and, consequently, drowning³⁷⁵. The Consumer Product Safety Commission has received reports of several deaths from extremely HOT WATER

³⁷⁵ Press E. The health hazards of saunas and spas and how to minimize them. Am J Public Health. 1991 Aug;81(8):1034-7.

(approximately 109° F) in hot tubs. In addition, high temperatures can lead to heat stroke and death³⁷⁶. Further examination of data on the health impact of high temperature water on pregnancy, particularly in the first trimester, is needed.

Minimum temperature requirements are not included in this CODE. Water that is too cold, simply will not be utilized for any extended period of time, and will not be used by individuals seeking a recreational water experience.

Even though minimum temperatures are not included in the CODE, it is important to remember that cold-water basins, such as PLUNGE POOLS, can present health concerns due to water temperature extremes.

These small, deep POOLS generally contain water at a temperature of 46-50° F and are used in conjunction with saunas or steam baths. Adverse health outcomes that may result from the intense and sudden changes in temperature associated with the use of these POOLS include immediate impaired coordination, loss of control of breathing and, after some time when the core body temperature has fallen, slowed heartbeat, hypothermia, muscle cramps and loss of consciousness. In general, exposure to temperature extremes should be avoided by pregnant women, users with medical problems and young children.⁶³

Spa Temperature

RM

SPA temperature maximum was based on the preponderance of state CODES that currently use this temperature and it is widely accepted and practiced in the industry. See discussion below in MAHC Annex 5.7.4.6.2 that recommends further evaluation.

Comfortable

RM

Water varying from 83-86°F (28-30° C) is the most comfortable temperature for typical water fitness classes. This allows the body to react and respond normally to the onset of exercise and the accompanying increase in body temperature. Cooling benefits are still felt and there is little risk of overheating. Program modifications will be required for water temperature outside the recommended range. Aquatic Fitness Professionals should know the water temperature and modify the program accordingly based upon the population and the program format.

Below Recommendation

RM

Water temperature below the recommended range requires modifications in programming. The primary focus of the warm up should be large, lower impact, rhythmic movements that gradually elevate core temperature of the body and should last for at least 9-15 minutes. The main segment must be of adequate intensity to maintain proper body temperature and prevent injury. Participants may find it necessary to wear specialized clothing to maintain body heat. The cool down and post-stretch must be adjusted, in overall length as well as activity, according to the environmental conditions. Water temperature above the recommended range also requires modifications in

³⁷⁶ United States Consumer Product Safety Commission. Spas, hot tubs, and whirlpools: Document # 5112. Accessed 2 March 2010 at <http://www.cpsc.gov/cpscpub/pubs/5112.html>.

programming. The intensity and length of the main segment should be adjusted to prevent overheating. Encourage proper hydration and apparel (e.g. avoid swimming caps that prevent heat dissipation). An extended cool down with emphasis on stretching and relaxation is appropriate.

5.7.4.5.2 Maximum Temperature

RM

SPA temperatures of 104°C are routinely used in SPAS and hot tubs across the United States. We are not aware of data that suggests this is too high for use by healthy individuals. Higher temperatures mimic a high fever in the human body and may not be healthy, particularly for prolonged use. However, the high temperature used in SPAS and hot tubs (MAHC sets it at 104°C maximum) necessitates strong signage to alert users about alcohol use and alert vulnerable groups about the risks potentially associated with use of SPAS and hot tubs. Review of the existing data (or collection of new data) is needed to inform the MAHC about whether a maximum length of time in a SPA should set.

Ethanol Use and Solo Use

RM

Ethanol use may contribute to the likelihood of drowning³⁷⁷. Low to moderate doses of ethanol did not appear to significantly impact body temperature or thermoregulatory response systems in healthy males at 104°C^{378,379}. However, there did appear to be INCREASED RISK of cardiac hypotension and fainting when users stood up that could result in slips or falls, the most common cause of SPA-related injury in the United States³⁸⁰. Several studies of sauna-related deaths in Scandinavia find a high percentage of alcohol use and that users were alone^{381,382}. Signage to restrict alcohol use, not to use SPAS when alone, and to exercise caution and use handrails to exit is warranted.

Pregnant Women

RM

Maternal hyperthermia has been shown to be associated with birth defects³⁸³. Some studies have shown an INCREASED RISK of birth defects and miscarriages associated with hot tub or SPA use during early pregnancy^{384,385,386,387}. Pregnant women, particularly during

³⁷⁷ Howland J, et al. Why are most drowning victims men? Sex differences in aquatic skills and behaviors. Am J Public Health 1996;86:93--6.

³⁷⁸ Allison TG, Reger WE. Thermoregulatory, cardiovascular, and psychophysical response to alcohol in men in 40 degrees C water. J Appl Physiol. 1992 Jun;72(6):2099-107.

³⁷⁹ Mekjavic IB, et al. Cardiovascular responses during 70 degrees head-up tilt: the effect of elevated body temperature and high alcohol blood levels. Physiologist. 1987 Feb;30(1 Suppl):S56-7

³⁸⁰ Alhaji M, et al. Hot tub, whirlpool, and spa-related injuries in the U.S., 1990-2007. Am J Prev Med. 2009 Dec;37(6):531-6.

³⁸¹ Rodhe A, Eriksson A. Sauna deaths in Sweden, 1992-2003. Am J Forensic Med Pathol. 2008 Mar;29(1):27-31.

³⁸² Kenttämies A, Karkola K. Death in sauna. J Forensic Sci. 2008 May;53(3):724-9.

³⁸³ Moretti ME, et al. Maternal hyperthermia and the risk for neural tube defects in offspring: systematic review and meta-analysis. Epidemiology. 2005 Mar;16(2):216-9.

³⁸⁴ Milunsky A, et al. Maternal heat exposure and neural tube defects. JAMA. 1992 Aug 19;268(7):882-5.

³⁸⁵ Duong HT, et al; National Birth Defects Prevention Study. Maternal use of hot tub and major structural birth defects. Birth Defects Res A Clin Mol Teratol. 2011 Sep;91(9):836-41.

³⁸⁶ Chambers CD. Risks of hyperthermia associated with hot tub or spa use by pregnant women. Birth Defects Res A Clin Mol Teratol. 2006 Aug;76(8):569-73.

³⁸⁷ Li DK, et al. Hot tub use during pregnancy and the risk of miscarriage. Am J Epidemiol. 2003 Nov 15;158(10):931-7.

the first trimester, should consult their physician before using hot tubs or SPAS. If women in later pregnancy choose to use hot tubs or SPAS, they should keep exposure to a minimum, and ensure the temperature is at or below recommended STANDARDS. Signage should alert pregnant women about the potential risks of hot tub or SPA use and the need to consult with their physician before use. Further expert review of the data is warranted to see if the data support reducing the water temperature and, if so, what temperature should be adopted to proactively protect women of childbearing age who may not know if they are pregnant.

Young Children

RM

Few studies exist looking at the impact of high temperature on young children although older children do appear to be able to control their temperature as well as adults³⁸⁸ but the high temperatures in saunas do put great demands on the circulatory system³⁸⁹. However, infants cannot control their body temperature as effectively as their older siblings and parents. This is because babies have a small body mass compared to body surface area. Being in water even a few degrees different from normal body temperature (98.6°F/37°C) can affect a baby's body temperature. Being in very warm or HOT WATER found in hot tubs/SPAS can cause hyperthermia, a dangerously high body temperature. Signage for SPAS and hot tubs should caution users about bring infants and young children into SPAS or hot tubs, particularly for prolonged use.

5.7.5 Water Quality Chemical Testing Frequency

Table 5.7.5: Water Testing Frequency Reference Chart

M&T

	Start-up*	Manual testing	Automated controllers	Closing*	Start-up*	Start-up*
Free Chlorine	Yes	2 hrs	4 hrs	Yes	-	-
Combined Chlorine	Yes	2 hrs	4 hrs	Yes	-	-
pH	Yes	2 hrs	4 hrs	Yes	-	-
TA	-	-	-	-	Yes	-
CH	-	-	-	-	-	Yes
CYA	-	-	-	-	-	Yes [†]
TDS	-	-	-	-	-	Yes
Microbiological	Testing shall be conducted after a fecal incident.					
* Manual testing to be done at these times						
† Unless TriChlor (trichloro-s-triazinetrione) or DiChlor (sodium dichloro-s-triazinetrione) are used for daily sanitizer or shock, then weekly						
Note: manual testing should be done after a significant weather event for outdoor facilities.						

³⁸⁸ Rowland T. Thermoregulation during exercise in the heat in children: old concepts revisited. J Appl Physiol. 2008 Aug;105(2):718-24.

³⁸⁹ Jokinen E, et al. Children in sauna: cardiovascular adjustment. Pediatrics. 1990 Aug;86(2):282-8.

5.7.5.1 Chemical Levels

M&T

When using colorimetric testing methods, combined CHLORINE testing consists of measuring free CHLORINE (FC), measuring total CHLORINE (TC), and subtracting the FC from the TC. When using titrimetric methods, it is easiest to perform a direct measure. The analyst should simply count each drop of titrant and multiply by the correct factor to attain the combine CHLORINE level.

A properly calibrated automatic chemical MONITORING system which maintains records and can be monitored remotely via a secure website could be acceptable for daily testing, if the system allows for the health department to have access to view a read-only log which monitors the chemistry at a facility.

5.7.6 Water Clarity

Water clarity is a useful measure of general water quality. Visual observation of main drains is important for BATHER SAFETY to avoid drowning incidents and injury prevention (for BATHER visibility). For POOLS, the use of a Secchi disk is not recommended.

For more information the limitations of Secchi disks, see:

- NOAA Technical Memorandum ERL PMEL-67, Eyeball Optics of Natural Waters: Secchi Disk Science, Rudolph W. Preisendorfer, Pacific Marine Environmental Laboratory, Seattle, WA, April 1986.

5.8 Decks and Equipment

5.8.1 Spectator Areas

5.8.1.1 Cross-Connection Control

RM

5.8.1.2 Materials/Slip Resistance

RM

5.8.1.2.3 Tripping Hazards

RM

ANSI defines where a trip hazard is considered as a level change that is greater than $\frac{1}{4}$ inch. Other definitions include an abrupt or unexpected level change in surfaces.

5.8.1.3 Deck Size/Width**5.8.2 Diving Boards and Platforms****5.8.3 Starting Blocks****5.8.4 Deck Slides****5.8.5 Lifeguard and Safety Related Equipment****5.8.5.1 Equipment Inspection and Maintenance LG**

The absence of this required equipment can adversely affect the effectiveness of a rescue and the SAFETY of the lifeguard. It could also hinder the response from emergency services. For this reason, it is the responsibility of the owner/operator to make sure this equipment is in place prior to opening the AQUATIC FACILITY to the public.

The equipment should be working so it can be used when needed. The word "safe" makes sure the equipment is not modified to be in working condition but posing a risk to the user.

5.8.5.2 Safety Equipment Required at All Aquatic Facilities LG**5.8.5.2.1 Communication Equipment LG****5.8.5.2.1.1 Functioning Communication Equipment LG**

As stated in the design section, emergency communication devices should be part of the design but also required to be present in the operation.

5.8.5.2.1.2 Hard Wired Telephone for 911 Call LG

- The AQUATIC FACILITY must be provided with the tools necessary for rapid and effective emergency communication. These tools might include a telephone, emergency band radio or other effective means of communication.
- Having a reliable telephone available during an emergency is important. Frequently cellular telephones, cordless telephones and other self-powered devices are not ready for use. Having a hard wired telephone provides that reliability.
- The telephone must be available to all AQUATIC VENUE users for use in an emergency, anytime the POOL is open for use. Pay telephones must be able to dial 911 without the use of coins or cards and maintained in an operable condition.
- The communication device should be placed in a manner where BATHERS can see and reach the device within about 1 minute and be placed so there are no obstructions to reaching it. The response time by the proper emergency agency has been shown to make a difference in patient outcome.³⁹⁰

³⁹⁰ EMS World Response Time Standards: <http://www.emsworld.com/article/10324786/ems-response-time-standards>

5.8.5.2.1.3 Alternate Communication Systems or Devices LG

The intent is that an emergency phone or communications system or device is immediately available to PATRONS from all AQUATIC VENUES within an AQUATIC FACILITY. Some alternate communication systems might include a handset or intercom system to a location that is constantly manned whenever the AQUATIC VENUE is open for use (e.g. a front desk at a hotel, the check in desk at a fitness club, or other continuously manned location); a commercial emergency contact device that connects to a MONITORING service, or directly to 911 dispatch; or devices that alert multiple staff on site when activated (e.g. pagers systems, cellular telephone systems and radio communication alert systems).

5.8.5.2.2 First Aid Equipment LG**5.8.5.2.2.1 Location for First Aid LG**

This is stated in the design section but also stated in the MAHC Operations section to require the operator to designate a first aid location for existing facilities. The supplies should be provided at locations where they can be quickly accessed by staff responding to emergencies.

5.8.5.2.2.2 First Aid Supplies LG

The first aid supply list is based on the ANSI /ISEA Z308.1-2009 STANDARD for a Workplace First Aid Basic Kit. The listed contents are based on the items needed, but the quantities are not specified to allow for flexibility based on the size of the AQUATIC FACILITY, the anticipated BATHER LOAD, anticipated number and types of injuries, and the number of first aid locations. Topical supplies such as antibiotic cream, burn gels, and antiseptics were removed because this poses a scope of practice issue for the level of training typical to lifeguarding.

The operator should provide enough supplies that the kit does not need continuous restocking. There should be enough supplies to last between first aid kit supply inspections, plus the time needed to obtain and replace the supplies. The contents should be inspected and resupplied often enough to maintain the supplies in good condition.

The supplies must be stored in such a manner as to protect them from moisture and extremes of heat and cold that will cause deterioration. Supplies must be periodically checked for expiration dates and replaced as needed.

A biohazard cleanup kit was included as lifeguards often deal with body fluids on surfaces such as vomit, feces, and blood. According to OSHA³⁹¹, "Generally, lifeguards are considered to be emergency responders and, therefore, would be considered to have occupational exposure. Emergency response is generally the main responsibility of lifeguards, therefore, such duties could not be considered collateral. Although it is the

³⁹¹ Occupational Safety and Health Administration (OSHA). Coverage of Lifeguards under 29 CFR 1910.1030. July 9, 1993. Corrected 08/16/2007. Accessed March 1, 2014 at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=21197

employer's responsibility to determine which, if any, of the employees have occupational exposure, employers of lifeguards should examine all facets of the lifeguard's emergency response duties, not just "retrieval from deep water." As a result, lifeguards are covered under OSHA 29 CFR 1910.1030 Bloodborne Pathogens standard, which speaks to having contact with individuals that may be injured and bleeding. As a result, employers are required to offer all the protections of the Bloodborne Pathogens STANDARD. Management should also consider how bloodborne pathogen training is integrated with training for environmental and/or water-based clean-up of feces and other body fluids (MAHC Section 6.5).

The Committee chose to compile this list after reviewing the contents of several kits that were commonly available.

One complete blood borne pathogen spill kit is needed at the AQUATIC FACILITY. Example of minimum suggested contents:

- Disposable gloves*,
- Disposal gown or apron, facemask, shoe covers,
- Face Shield,
- Anti-microbial wipes,
- Biohazard Bag,
- Disinfectant (ex. calcium hypochlorite packet – 1 oz.),
- Absorbent materials or fluid solidifier (~20gm),
- Scoops for solidified material,
- Scraper, and
- Instructions for use.

*Do not use latex gloves. Gloves should be single use, vinyl or nitrile and non-powdered. Gloves should be disposed of after one use. Fit is important. It is recommended that 4 to 6 mil. gloves be used.

** It is suggested that a kit be assembled, put in a container and sealed to assure the contents are still intact when needed. After use, a new kit is provided or the container is restocked and resealed.

In addition to the AQUATIC FACILITY kit, lifeguards should carry basic PPE for immediate use during initial exposure to feces, vomit and small amounts of blood until the full kit arrives at the treatment scene as described in MAHC Section 5.8.3.9.

AEDs were considered to be included in this list, but due to the requirement for medical direction for AED use by trained rescuers, it was not included as it may not be within the AHJ's authority to mandate such equipment. However, AEDs are widely used and can be used for submersion events and any cardiac incident. If local protocols can be established, it is recommended to have an AED.

5.8.5.2.3 Signage

5.8.5.2.3.1 Sign Indicating First Aid Location LG

Effective signage must communicate where first aid assistance can be obtained. This is especially important in smaller AQUATIC FACILITIES and at AQUATIC FACILITIES not requiring lifeguards where the first aid station might be outside the immediate AQUATIC VENUE area. Signage is also important at very large AQUATIC FACILITIES where the first aid station might be harder to find. Effective signage should follow the STANDARDS established by ICC A117.1-2009 and ADA Accessibility Guidelines including sign height, raised or Braille lettering, and placement.

Emergency telephones or communication devices are usually in conspicuous locations; however, those locations should be communicated so BATHERS and staff alike know where they are and can rapidly locate them.

5.8.5.2.3.2 Emergency Dialing Instruction LG

Signage must be posted at the telephone or approved communication system or device with emergency contact number(s) or procedures and the address of the AQUATIC FACILITY. Often a person in an emergency situation can be confused, so having the address of the AQUATIC FACILITY, emergency number(s) at the telephone, and special instructions, if any, makes responding easier.

5.8.5.2.3.3 Management Contact Info LG

An owner/operator contact number must be provided for notification of water quality and SAFETY concerns. At AQUATIC FACILITIES where QUALIFIED OPERATORS are not present at all times, it is important for PATRONS to be able to contact the owner/operator when water quality has been compromised (ex. cloudy water, fecal matter in the water, and/or other issues of concern related to water quality or SAFETY).

5.8.5.2.3.4 Hours of Operation LG

Operating hours for an AQUATIC FACILITY should be posted and clearly visible at the AQUATIC FACILITY, especially when the AQUATIC FACILITY is not attended at all times by an operator or lifeguard.

5.8.5.3 Safety Equipment Required at Aquatic Facilities with Lifeguards LG**5.8.5.3.1 UV Protection for Chairs and Stands LG**

In the design section, permanently installed chairs and stands are required to be designed with UV protection. In the Operations section, it is required to have the UV protection present. Regardless of when the chair or stand was constructed, UV protection is required to protect the lifeguard from an occupational exposure.

5.8.5.3.2 Spinal Injury Board LG

Spinal injury boards facilitate immobilization of a person with a suspected spinal injury. Because these boards are often used in or around the water, their construction should be of materials that can withstand the environment and be easily SANITIZED/disinfected between uses. Boards must be properly maintained and in good repair. An example is

using a wooden backboard that is worn so the wood is exposed and no longer cleanable. In this case refinishing it with a waterproof finish should again make it cleanable. The head immobilizer and straps are commonly used in lifeguard training programs and these tools assist in the immobilization of a person on the board and should be present during operation. Deciding which straps to be included should consider how to best immobilize the person to the board. Common locations for straps are at the upper torso, the hips, and legs.

The number of spine boards available at the AQUATIC FACILITY should be dependent on the size of the AQUATIC FACILITY. It would be difficult to determine the exact number but a general consideration should be to have a spine board reach the location it is needed within a couple of minutes. There should not be a delay: the person needing to be extricated from the water will need to be held in an immobile position in the water. To extricate without a spine board can cause more damage to the person.

5.8.5.3.3 Rescue Tube Immediately Available LG

The 50th percentile adult is at least 64 inches (1.6 m) tall. The rationale is that the average adult BATHER's head would be above the static water line and they could use the AQUATIC VENUE without difficulty. Due to buoyancy considerations at chest level, a short lifeguard could have difficulty doing a rescue safely without equipment. For this reason, the rescue tube is required unless there is less than 3 feet (0.9 m) of depth in which their chest would likely be above the static water line.

Lifeguard training agencies have determined that the use of a rescue tube makes rescues safer for both the victim and the rescuer. The rescue tube provides a BARRIER between the victim and the rescuer as well as a handhold for both during a rescue.

In very shallow water, the rescue tube may not be as effective so the language in the code is flexible to allow for the rescue tube to be available immediately, but is not required to be worn. However, as stated above, the rescue tube provides protection for the lifeguard so the operator should determine the level of risk and requirement for wearing the rescue tube based on the AQUATIC VENUE depth, activities, and frequency of rescue.

5.8.5.3.4 Rescue Tube on Person LG

Being properly prepared to respond to an emergency requires wearing the harness strap attached to the rescue tube and keeping the rescue tube in a position and location where it can be immediately used.

It is important to wear the rescue tube in a rescue ready position. Wearing the strap and sitting with the tube at the lifeguard's feet, or in any other position except held against the body, can lead to situations where a lifeguard is injured or cannot respond because the tube's strap is wrapped around handrails, chair pedestals or other catch points. Management should reinforce through pre-service, in-service, and employment policy that the lifeguards are expected to hold the rescue tube in a manner taught and accepted by the lifeguard training agency.

5.8.5.3.5 Identifying Uniform**LG**

There should be no delay in care because a PATRON is unable to find a member of the AQUATIC FACILITY SAFETY TEAM. Distinct uniforms are a STANDARD in most industries to identify workers and their assigned tasks.

5.8.5.3.6 Signal Device**LG**

The most basic communication method used by lifeguards is a combination of whistle blasts and hand signals to communicate with each other, PATRONS, and management. Whistle signals can communicate when to clear the POOL, get another lifeguard's or supervisor's attention and communicate emergencies.

The devices and their use can vary depending on the AQUATIC FACILITY and its management. Because of inherent background noise, whistles, hand signals, emergency buttons, radios, and telephone handsets are used to provide more effective communication.

5.8.5.3.7 Sun Blocking Methods**LG**

Protection from direct sun exposure is a necessary part of lifeguarding at AQUATIC FACILITIES. Gone are the days when the objective of the lifeguard was to get as deep a tan as possible. Today, sun exposure, especially when the skin becomes burned, increases significantly the risk of skin cancers.

In a recent study of melanoma, it was noted that the melanoma DNA contained 33,000 mutations, many of which may have come from ultraviolet light exposure³⁹².

The best sunscreens available at the present time are broad spectrum or full spectrum and are usually so labeled. More will probably become available as new Food and Drug Administration rules are implemented³⁹³. These protect against both UVA and UVB rays as long as re-application is conducted periodically. Because SPF ratings only measure UVB effectiveness there is a lot of variability in UVA protection in sunscreens. The CDC recommends a sunscreen with an SPF of at least 15³⁹⁴.

There are some questions about the health effects of some of the screening chemicals, but the benefits seem to outweigh the hazards. To minimize exposure to these chemicals, lifeguards should also wear protective clothing, hats, use sun-blocking umbrellas, or any other means to avoid exposure to UV light. Protection is also needed from reflected exposure. Light-skinned individuals can be particularly sensitive to both direct as well as indirect exposure to the sun's UV rays³⁹⁵. Employers should educate lifeguards about the risk and protection options but are exempted from requirements to

³⁹² Pleasance ED, et al. A comprehensive catalogue of somatic mutations from a human cancer genome. Nature. 2010;463;7278;191-6. PUBMED:20016485; DOI:10.1038/nature08658.

³⁹³ 21 CFR Parts 201 and 310, Labeling and Effectiveness Testing; Sunscreen Drug Products for Over-the-Counter Human Use.

³⁹⁴ CDC/NIOSH. UV Radiation [online]. [cited 2014 Feb 6.] Available from: <http://www.cdc.gov/niosh/topics/uvradiation/>.

³⁹⁵ IARC monographs on the evaluation of carcinogenic risks to humans. Solar and ultraviolet radiation. IARC Monogr Eval Carcinog Risks Hum. 1992;55:1-316. PMID:1345607

pay for sunscreen as personal protective equipment according to OSHA 1910.132(h)(4)(iii)³⁹⁶.

5.8.5.3.8 Polarized Sunglasses

LG

Glare and reflected sunlight off the water surface can cause significant visibility problems for lifeguards and potentially impact job performance. Lifeguards working at outdoor venues are required to wear polarized eye wear to reduce the risk of glare causing reduced visibility. This polarized eyewear should also be a part of any sun exposure awareness training since it also potentially reduces the harmful short- and long-term effects of UV on eyes that include INCREASED RISK for cataracts and macular degeneration^{397,398,399,400,401,402,403}. However, employers are exempted from requirements to pay for sunglasses as personal protective equipment according to OSHA 1910.132(h)(4)(iii)⁴⁰⁴.

Polarized eyewear can assist with glare indoors as well but should be tested so it does not impede visibility due to lower light levels.

Polarized 3-D glasses must not be used as they can be disorienting and can disrupt normal vision.

5.8.5.3.9 Personal Protective Equipment

LG

Appropriate personal protective equipment (PPE) must be provided to all employees that have possible occupational exposures. Lifeguards should carry or have immediately available basic PPE (disposable gloves and CPR mask) for immediate use during initial exposure to feces, vomit, and small amounts of blood until the full facility bloodborne pathogen kit arrives at the treatment scene. This could be in a small pouch to be carried on the lifeguard, a pouch associated with the rescue tube, or at a location near the lifeguard position. The intent is that the lifeguard does not need to leave the immediate area to find PPE nor will it create a delay in response.

OSHA Blood borne Pathogen Regulations⁴⁰⁵, require that the employer shall provide, at no cost to the employee, appropriate personal protective equipment such as, but not

³⁹⁶ Occupational Safety and Health Administration (OSHA). Personal Protective Equipment standard 1910.132 Accessed March 1, 2014 at

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777

³⁹⁷ Krutmann J et al. Towards standardization of UV eye protection: what can be learned from photodermatology? Photodermatol Photoimmunol Photomed. 2013 Nov 8. doi: 10.1111/phpp.12089.

³⁹⁸ Glickman RD. Ultraviolet phototoxicity to the retina. Eye Contact Lens. 2011 Jul;37(4):196-205.

³⁹⁹ Roberts JE. Ultraviolet radiation as a risk factor for cataract and macular degeneration. Eye Contact Lens. 2011 Jul;37(4):246-9.

⁴⁰⁰ Glickman RD. Phototoxicity to the retina: mechanisms of damage. Int J Toxicol. 2002 Nov-Dec;21(6):473-90.

⁴⁰¹ McCarty CA et al. A review of the epidemiologic evidence linking ultraviolet radiation and cataracts. Dev Ophthalmol. 2002;35:21-31.

⁴⁰² Roberts JE. Ocular phototoxicity. J Photochem Photobiol B. 2001 Nov 15;64(2-3):136-43.

⁴⁰³ Taylor HR. Ultraviolet radiation and the eye: an epidemiologic study. Trans Am Ophthalmol Soc. 1989;87:802-53.

⁴⁰⁴ Occupational Safety and Health Administration (OSHA). Personal Protective Equipment standard 1910.132 Accessed March 1, 2014 at

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777

⁴⁰⁵ 29 CFR 1910.1030, Toxic and Hazardous Substances – Blood borne Pathogens

limited to, gloves, gowns, laboratory coats, face shields or masks and eye protection, and mouthpieces, resuscitation bags, pocket masks, or other ventilation devices. Personal protective equipment will be considered "appropriate" only if it does not permit blood or other potentially infectious materials to pass through to or reach the employee's work clothes, street clothes, undergarments, skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time which the protective equipment will be used.

5.8.5.3.10 Rescue Throwing Device **LG**

If the single lifeguard is engaged in a rescue and another person is in distress, the rescue throw device allows for an untrained individual to assist the distressed person.

5.8.5.3.11 Reaching Pole **LG**

If the single lifeguard is engaged in a rescue and another person is in distress, the reaching pole allows for an untrained individual to assist the distressed person.

5.8.5.4 Safety Equipment Required at Aquatic Facilities without Lifeguards **LG**

5.8.5.4.1 Throwing Device **LG**

A rescue throwing device is a throw bag, buoyant life ring, torpedo buoy or other easily thrown buoyant device that is designed for a person on the DECK to throw it to a person in distress in the AQUATIC VENUE. Fifty feet (15.2 m) of minimum ¼ inch (6.4 mm) rope securely attached to the device is required. It has been found that untrained individuals have a reasonable ability to reach 30 feet (9.1 m) with a rescue throw device. A 50 foot (15.2 m) rope would accommodate that distance. The 1.5 times the width of the POOL allows for a SAFETY factor to overthrow the device and pull the rope back toward the person in distress. This also allows for extra rope to hold on to. The device must be kept ready for use, and the rope must be coiled to prevent tangles and to facilitate throwing the device.

5.8.5.4.2 Reaching Pole **LG**

The pole is intended to reach out to a swimmer in distress and to allow them to grab hold of the pole. The pole should be submerged when introducing it to the swimmer to prevent injury. In some cases the "hook" can be used to encircle a non-responsive swimmer to draw them to the side. Use of the device involves reaching out to the swimmer and then pulling the pole straight back to the side, along with the swimmer. The pole cannot be swung around to the side as the strength required exceeds that of most people, and the pole is not that durable.

Since the pole is pulled back to the side, a telescoping pole is not appropriate as it can pull apart. Ideally the pole can reach to the middle of many smaller POOLS making the entire POOL reachable from the side with the pole.

The pole must be equipped with a "life-hook" or "shepherd's crook". For SAFETY, the hook must be a looped frame-type hook, not the single metal hook. The hook protects

the swimmer from being injured by the pole, as well as allows a non-responsive swimmer to be pulled in. To prevent injury, use only the hook attachment bolts supplied by the manufacturer. This will prevent hooks and snags, caused by using the improper bolts, which can injure the swimmer.

5.8.5.4.3 CPR Posters

LG

CPR performed by bystanders has been shown to improve outcomes in drowning victims⁴⁰⁶. CPR started immediately on a drowning victim instead of waiting until emergency responders arrive will have a significant effect on the potential for brain damage in the victim. Posters of CPR explaining basic procedures can be reviewed in seconds and give the provider enough knowledge to assist the victim until emergency responders arrive.

Posters can educate PATRONS to recognize potential causes of, prevention, and spread of RWIs. PATRONS need to be educated to what RWIs are, how they are spread, and how they can be prevented.

Resources for RWI education can be found at <http://www.cdc.gov/healthyswimming>. There are many resources for CPR posters that can be found online.

5.8.5.4.4 Imminent Hazard Sign

LG

A sign indicating reasons requiring closure especially at AQUATIC FACILITIES where a QUALIFIED OPERATOR or QUALIFIED LIFEGUARD is not present should be posted listing specific incidents which would require the AQUATIC FACILITY to immediately close. Examples of such incidents include fecal incidents, broken/missing drain grates, water clarity, and lightning. A contact number should be provided to notify the owner/operator of conditions considered an IMMEDIATE HEALTH HAZARD.

5.8.5.4.5 Sign for Conditions When Qualified Lifeguard is Required

LG

MAHC Section 6.3.1.1.4 outlines the conditions that require a QUALIFIED LIFEGUARD. For AQUATIC FACILITIES that do not have lifeguards, PATRONS should be informed that no lifeguard is provided so they can comply with any requirements and understand the identified risk. For instance, at a hotel POOL that requires key entry, the sign would notify hotel guests that no lifeguard is provided and persons under the age of 14 are not allowed in without adult supervision.

5.9 Filter/Equipment Room

5.9.1.1 Local Codes

RM

All chemical containers must be labeled with the following information:

- Chemical identity,

⁴⁰⁶ Kyriacou DN, et al. Effect of immediate resuscitation on children with submersion injury. *Pediatrics*. 1994;94(2):137-142.

- Manufacturer's name and address,
- Physical hazards,
- Health hazards, and
- Degree or type of risk.

The label should explain necessary precautions to take; how to handle, store, and dispose of chemicals; and sometimes indicate hazard potential with a number from 0 to 4. This number indicates the degree of risk, with the number 4 representing the greatest risk, and shows the hazard categories (see NFPA 704).

5.9.1.2 OSHA and EPA

RM

Chemicals shall never be pre-mixed with water by hand before adding the chemical to the AQUATIC VENUE unless specified by the manufacturer. If a dissolution or feed tank is used to dissolve product for feeding into the AQUATIC VENUE, the tank must be equipped with a mechanical mixer, dedicated to a single chemical and clearly labeled to prevent the introduction of incompatible chemicals to the tank. Chemicals shall be added to water, water shall never be added to chemicals. Pre-mixing in containers that are not clean can result in the generation of heat and toxic gases and may result in fire or explosion.

Oxidizers such calcium hypochlorite, monopersulfate or bleach shall not be mixed with any other chemicals.

5.9.1.3 MSDS

RM

A material safety data sheet (MSDS) is a form containing data, potential hazard information, and instructions for the safe use of a particular material or product. An important component of product stewardship and workplace SAFETY, it is intended to provide workers and emergency personnel with procedures for handling or working with that substance in a safe manner, and includes information such as physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, impact on the environment, first aid, reactivity, STORAGE, disposal, protective equipment, and spill handling procedures. The exact format of an MSDS can vary from source to source. It is important to use an MSDS that is supplier-specific as a product using a generic name (e.g. oxidizer) can have a formulation and degree of hazard which varies between different manufacturers.

Filed

RM

MSDSs should be filed anywhere chemicals are being used. An MSDS for a substance is not primarily intended for use by the general consumer, focusing instead on the hazards of working with the material in an occupational setting.

OSHA

RM

In the U.S., the Occupational Safety and Health Administration (OSHA) requires that MSDSs be available to employees for potentially harmful substances handled in the workplace under the Hazard Communication regulation. The MSDS is also required to be made available to local fire departments and local and state emergency planning

officials under Section 311 of the Emergency Planning and Community Right-to-Know Act.

Hazard Ratings^{RM}

The MSDS will typically contain the hazard ratings according to either the NFPA or HMIS systems. The NFPA system may be found in *NFPA 704: STANDARD System for the Identification of the Hazards of Materials for Emergency Response*. In the NFPA system, the chemicals are rated according to their health, flammability, instability, and special hazards. The degree of hazard is indicated by a number from 0 to 4, with 0 being the least hazardous and 4 being the most hazardous. Either HMIS or NFPA ratings are useful to include on product labels. Most fire CODES require these ratings to be posted on chemical STORAGE room doors.

5.9.1.5 Protected

^{RM}

In addition to the requirements listed in MAHC section 5.9.1.5, the following BEST PRACTICES are recommended:

- Place all chemical containers, drums, boxes, and bags on pallets to raise them off the floor.
- Containers should not be stacked so that they will easily fall over. A general rule of thumb is that they should not be stored more than three high.
- Containers of chemicals shall be closed securely to prevent contamination.
- Any shelving units used to store chemicals should be sturdy enough to support the weight of the chemicals being stored.

5.9.1.6 No Mixing

^{RM}

Particularly keep chlorinated cyanurates, hydantoin bromine, and calcium hypochlorite away from other chemicals, paper, water, petroleum products, or other organic compounds to avoid possible cross-contamination.

No liquids should be stored above solids.

Chemicals must be stored in the original manufacturers' labeled container. STORAGE containers that held other chemicals previously are unacceptable. Chemicals may be transferred from the original container to a new container if that container was manufactured for the STORAGE of that chemical and properly labeled.

Aquatics staff should read and consider findings and recommendations developed from investigations related to POOL chemical-related injuries. See "CDC Recommendations for Preventing POOL Chemical-Associated Injuries" at <http://www.cdc.gov/healthywater/swimming/POOLS/preventing-POOL-chemical-injuries.html>

5.9.1.7 Ignition Sources

^{RM}

National Fire Protection Association (NFPA), Hazardous Material Identification System (HMIS), or equivalent hazard rating systems may be used.

5.9.1.9 Lighting**RM**

Horizontal-plane illumination must be adequate for SAFETY and navigation, as well as for reading documents.

The Illuminating Engineering Society of North America (IESNA) recommends a 30 footcandle (323 lux) minimum for Motor & Equipment Observation.

5.9.1.10 PPE**RM**

Common components of PPE for chlorinated AQUATIC VENUE chemicals are as follows:

- Respiratory Protection: Wear a NIOSH approved respirator if levels above the exposure limits are possible.
- Respirator Type: A NIOSH approved full-face air purifying respirator equipped with combination CHLORINE/P100 cartridges. Air purifying respirators should not be used in oxygen deficient or IDLH atmospheres or if exposure concentrations exceed ten (10) times the published limit.
- Skin Protection: Wear impervious gloves to avoid skin contact. A full impervious suit is recommended if exposure is possible to a large portion of the body. A SAFETY shower should be provided in the immediate work area.
- Eye Protection: Use chemical goggles. Emergency eyewash should be provided in the immediate work area.
- Protective Clothing Type: Neoprene, Nitrile, Natural rubber (This includes: gloves, boots, apron, protective suit).

5.10 Hygiene Facilities**5.10.1 General****5.10.2 Location [N/A]****5.10.3 Bathhouse Design [N/A]****5.10.4 Fixture Requirements****5.10.4.1 General Requirements****HYG****5.10.4.1.1 Cleaned and Sanitized****HYG**

Toilets and showers should appear clean and ready to use to attract BATHERS to use them.⁴⁰⁷

Although the MAHC is not aware of any work in this particular setting, studies in child care settings, schools, long term care facilities and food service establishments all support the importance of surface cleaning. The MAHC feels that daily cleaning at a minimum in this setting is reasonable for aesthetics as well as health and SAFETY.

⁴⁰⁷ Pool Water Treatment Advisory Group. Swimming pool water; Treatment and quality standards for pools and spas. 2nd edition, 2009. Micropress Printers Ltd.

5.10.4.2 **Cleansing Showers** **HYG**

5.10.4.3 **Rinse Showers** **HYG**

5.10.4.3.4 **No Soap** **HYG**

Soap is not needed at RINSE SHOWERS because it can have a negative effect on POOL chemistry.

5.10.4.4 **All Showers** **HYG**

5.10.4.5 **Diaper-Changing Stations** **HYG**

5.10.4.5.1 **Cleaned** **HYG**

It is the responsibility of PATRONS to clean diaper changing surfaces after each use. This is consistent with practice in other public settings where diapering takes place. However, staff should keep an eye on stations and clean when necessary.

5.10.4.6 **Non-Plumbing Fixture Requirements** **HYG**

5.10.4.6.4 **Floor Coverings** **HYG**

Associations between swimming POOLS and disease outbreaks have been well documented in the literature. Though an outbreak has never been connected to the materials used specifically, wood and other porous materials have been shown to have bacterial growth on them that can be hard to remove.

Non-porous materials used as matting at AQUATIC FACILITIES were found to be contaminated with bacteria and biofilm scum layers, although conventional cleaning was documented to remove the contamination⁴⁰⁸.

Biofilms are a complex collection of microbes that attach to a wet surface and form a scum layer that harbors bacteria and other microbes that could cause illness. Once established, biofilms provide a home for a variety of microbes such as Pseudomonas and are hard to remove. Biofilm-associated bacteria are much more resistant to hypochlorous acid compared to free swimming microbes. Design options to reduce biofilm formation as well as sanitizing systems with effective validation, could be useful for reducing biofilm formation.

5.10.5 **Provision of Suits, Towels, and Shared Equipment**

5.10.5.1 **Towels** **HYG**

The drying temperature is more important than the wash temperature when destroying potential pathogens. CDC recommendations for laundering entitled, "Environmental Cleaning & Disinfecting for MRSA" can be found at <http://www.cdc.gov/mrsa/environment/Laundry.html>.

⁴⁰⁸ Davis TL, et al. Bacteriological analysis of indoor and outdoor water parks in Wisconsin. J Water Health 2009;7(3):452-463.

5.10.5.3 Shared Equipment Cleaned and Sanitized**HYG**

Research has demonstrated that play features, mat materials, and other shared equipment found at AQUATIC FACILITIES and water parks can harbor bacteria, even while submerged in chlorinated water. Damp materials that were not submerged in water contained the highest populations of bacteria. Damp play features designed for infants and toddlers were found to be likely vehicles for transference of gastrointestinal bacteria.¹⁹

Sanitization is defined as reducing the level of microbes that are considered safe by public health STANDARDS. This may be achieved through a variety of chemical or physical means including chemical treatment, cleaning, or drying.

Associations between swimming POOLS and disease outbreaks have been well-documented in literature. Though an outbreak has never been connected to play features or the type of play feature material specifically, the possibility could exist due to biofilms found on these materials. Outbreaks may be more likely if the AQUATIC FACILITY is not maintained properly.

Biofilms are a complex collection of microbes that attach to a wet surface and form a scum layer that harbors bacteria and other microbes that could cause illness. Once established, biofilms provide a home for a variety of microbes such as Pseudomonas and are hard to remove. Biofilm-associated bacteria are much more resistant to hypochlorous acid compared to free swimming microbes. Design options to reduce biofilm formation as well as sanitizing systems with effective validation, could be useful for reducing biofilm formation.

Contact**HYG**

Shared equipment that contact mucous, saliva, eyes, or ears require sanitizing to prevent transmission of potential disease causing pathogens.

5.10.5.4 Other Equipment**HYG**

Shared equipment which is hand held or used as a flotation device used in aquatic therapy or play have also been found to harbor potential harmful microorganisms, even while submerged in properly chlorinated water. Bacteria found in these environments are most likely from biofilms that have attached to these surfaces. Soaking in disinfectants may not be enough to penetrate the biofilm; so to control biofilm growth, it is recommended to physically remove the slimy film by scrubbing equipment on a routine basis. The array of organisms isolated from damp features suggests that features need to be cleaned, SANITIZED, and thoroughly dried on a routine basis using a combination of chemical and physical methods, preferably as recommended by the manufacturer.⁴⁰⁹

⁴⁰⁹ Pool Water Treatment Advisory Group. Swimming pool water; Treatment and quality standards for pools and spas. 2nd edition, 2009. Micropress Printers Ltd.

5.11 Water Supply/ Wastewater Disposal

5.12 Special Requirements for Specific Venues

5.12.1 Water Slides

5.12.2 Wave Pools

5.12.3 Moveable Floors

5.12.4 Bulkheads

5.12.5 Interactive Water Aquatic Venues

5.12.6 Wading Pools

5.12.7 Spas

5.12.7.5 Water Replacement

R&F

For example, a 600 gallon SPA divided by 3 yields 200 divided by 25 (the average users per day) produces an 8 day water replacement interval.

6.0 Policies and Management

6.0.1 Staff Training

6.0.1.8 Body Fluid Exposure

RM

CDC's Healthy Swimming Site (<http://www.cdc.gov/healthywater/swimming>) contains additional information on Recreational Waterborne Illnesses (RWI). Employees should not swallow the AQUATIC VENUE water and should thoroughly wash their hands after the response.

- See OSHA 1910.1030 Bloodborne Pathogens: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10051.
- CDC's guidance on Cleaning Up Body Fluid Spills on POOL Surfaces: <http://www.cdc.gov/healthywater/swimming/POOLS/cleaning-body-fluid-spills.html>

6.1.1 Operator Qualifications and Certification

POOL and SPA operation and maintenance violations are common.

POOL inspection data from 15 jurisdictions across the United States indicate that over half (61.1%) of inspections identified ≥ 1 violation(s) and 12.1% of inspections resulted in immediate closure because of the seriousness of identified violation(s). In addition, violations regarding the following issues were frequently identified:

- Disinfectant level (10.7% of inspections),
- pH level (8.9%),
- Other water chemistry (12.5%),
- Filtration/RECIRCULATION SYSTEM (35.9%),
- Water test kit (3.3%),
- Record keeping 10.9%), and
- Licensure (2.7%).⁴¹⁰

Review of SPA inspection reports from these same jurisdictions found over half (56%) of inspections identified ≥ 1 violation(s) and 11% of inspections resulted in immediate closure because of the seriousness of identified violation(s). In addition, SPA inspection data indicated that the following violations regarding the following issues are frequently identified:

- Disinfectant residual (17% of inspections),
- pH level (15%),
- Other water chemistry (17%),
- Filtration/RECIRCULATION SYSTEM (27%),

⁴¹⁰ Centers for Disease Control and Prevention. Violations identified from routine swimming pool inspections – selected states and counties, United States, 2008. MMWR Morb Mortal Wkly Rep. 2010;59(19):582-587.

- Water test kit (2%), and
- Record keeping (13%).⁴¹¹

The authors conclude that the number of overall violations highlights the need for POOL and SPA staff training, which includes information about recreational water illness (RWI) transmission, and the potential benefits of mandating training for POOL operators throughout the United States. In addition, it underscores the need for operator training courses to include the topic areas related to the common violations listed above.

The PATHOGENS causing approximately one third of reported RWI outbreaks associated with treated facilities are CHLORINE sensitive. This CHLORINE sensitivity of PATHOGENS involved in outbreaks indicates that these AQUATIC FACILITIES were poorly operated or maintained. The authors conclude that preventing recreational water illness outbreaks, particularly those associated with inadequate public operation of AQUATIC FACILITIES, calls for required POOL and SPA operator training.⁴¹²

Of 36 reported POOL chemical-associated health events in New York State (1983–2006), 69% (25) were caused by poor chemical handling or STORAGE practices and 81% (27) resulted from mixing incompatible chemicals. The authors conclude that preventing these events calls for educating public POOL operators and residential POOL owners about safe chemical handling and STORAGE practices.⁴¹³

Operator training reduces pool inspection violations.

Two studies have shown that POOLS with operators who have successfully completed formal training in POOL operation, have better water quality than POOLS without a trained operator.

Results from a study in Nebraska demonstrated that FREE CHLORINE violations and concurrent pH and FREE CHLORINE violations were twice as likely in local jurisdictions not requiring certification compared with jurisdictions requiring training. The authors conclude that these results demonstrate the benefit of requiring POOL operator certification to help prevent recreational water illnesses.⁴¹⁴

6.1.2 Essential Topics in Qualified Operator Training Courses

OT

POOL inspection data from 15 jurisdictions across the United States indicated that 12.1% of inspections resulted in immediate closure because of the seriousness of

⁴¹¹ Centers for Disease Control and Prevention. Surveillance data from public spa inspections — United States, May–September 2002. *MMWR Morb Mortal Wkly Rep.* 2004;53(25):553–555.

⁴¹² Yoder J, Hlavsa M, Craun GF, Hill V, Roberts V, Yu P, Beach MJ. Surveillance for waterborne disease and outbreaks associated with recreational water use and other AQUATIC FACILITY-associated health events — United States, 2005–2006. *MMWR Surveill Summ* 2008;57:1-38

⁴¹³ Centers for Disease Control and Prevention. Pool chemical-associated health events in public and residential settings — United States, 1983-2007. *MMWR Morb Mortal Wkly Rep.* 2009;58(18):489-493.

⁴¹⁴ Buss BF, Safranek TJ, Magri JM, Török TJ, Beach MJ, Foley BP. Association between swimming pool operator certification and reduced pool chemistry violations — Nebraska, 2005–2006. *J Environ Health.* 2009;71(8):36–40.

identified violations and violations regarding the following issues are frequently identified:

- FREE CHLORINE level (10.7% of inspections),
- pH level (8.9%),
- other water chemistry (12.5%),
- filtration/RECIRCULATION SYSTEM (35.9%),
- water test kit (3.3%),
- record keeping 10.9%), and
- licensure (2.7%).⁴¹⁵

SPA inspection data indicated that the following violations regarding the following issues are frequently identified:

- disinfectant residual (17% of inspections),
- pH level (15%),
- other water chemistry (17%),
- filtration/RECIRCULATION SYSTEM (27%),
- water test kit (2%), and
- record keeping (13%).⁴¹⁶

These analyses underscore the need for inclusion of these topic areas in QUALIFIED OPERATOR courses. These essential topics are covered in nationally recognized operator training courses.

6.1.2.1 Course Content

OT

6.1.2.1.1 Water Disinfection

OT

Many other DISINFECTION chemicals or systems with varying effectiveness and suitability are being offered in the market to AQUATIC FACILITY operators for water treatment. In general terms, discuss the evaluation steps that should be used by the AQUATIC FACILITY operator, including required AHJ acceptance of the chemicals or systems for public AQUATIC FACILITIES, in their decision process on using these types of supplemental systems or treatments.

- *Disinfectants* –Training should address OSHA “Right-to-Know” and Hazard Communication STANDARDS and other SAFETY aspects.
- *CHLORINE* – Special emphasis should be given to safe handling of erosion feeders/chemical mixing. See Annex 4.9.2 for discussion on chemical injuries
- *Combined CHLORINE* – A discussion of deterioration of buildings, machinery, and structures due to the effects of airborne chloramines in INDOOR AQUATIC FACILITIES is appropriate.

⁴¹⁵ Centers for Disease Control and Prevention. Violations identified from routine swimming pool inspections – selected states and counties, United States, 2008. MMWR Morb Mortal Wkly Rep. 2010;59(19):582-587.

⁴¹⁶ Centers for Disease Control and Prevention. Surveillance data from public spa inspections — United States, May–September 2002. MMWR Morb Mortal Wkly Rep. 2004;53(25):553–555.

- *Secondary DISINFECTION* – It is appropriate to include a discussion of the effectiveness of in-line treatment versus side stream treatment.
- *Supplemental DISINFECTION* – It is appropriate to include a discussion of the effectiveness of in-line treatment versus side stream treatment.
- *Water Balance* – Water balance elements may also include options for treatment including priority of factors to be adjusted.
- *Water Clarity* – Discussions should include treatment priorities to improve clarity.
- *pH* – It is also important to remember that there are limits on Phenol Red readings when very low or very high pH readings occur.
- *Mechanical Systems* – Common current alternative filter media types that can be mentioned include perlite, zeolite, and food-grade cellulose.
- *Circulation Pump & Motor* – The operator should also become familiar with submerged pumps such as turbine, mixed flow, and others used in waterpark applications. Additionally, the operator needs to have an understanding of the winterizing needs for these types of equipment.
- *Filter Backwashing/Cleaning* – In these days of energy and water conservation, it is increasingly important that water conservation be practiced. Backwash water can be responsible for wasting an unnecessary amount of water if not done properly or too frequently.

If properly treated to meet water quality STANDARDS, AQUATIC FACILITIES can obtain savings with water costs. However, in some cases, it may not be cost effective for an AQUATIC FACILITY to expend funds on retreatment of backwash water. In those cases, it is most important that all water is discharged properly in accordance with the regulations of the local jurisdiction.

6.1.2.1.2 **Water Chemistry**

6.1.2.1.3 **Mechanical Systems**

OT

6.1.2.1.4 **Health and Safety**

OT

6.1.2.1.4.1 **Recreational Water Illness**

The number of outbreaks associated with recreational water has continued to substantially increase since reporting began in 1978, most notably in 1982, 1987, 2004, and 2007. CDC recommends that public health and the aquatic sector collaborate on educating the swimming public, an important source of recreational water contamination, about RWIs and what swimmers can do to protect themselves and others.⁴¹⁷

6.1.2.1.4.3 **RWI Prevention**

The operator should be aware of the need for frequent manual testing, standardization of automatic controllers, and adequately sized chemical feeders.

⁴¹⁷ Yoder J et al. Surveillance for waterborne disease and outbreaks associated with recreational water use and other AQUATIC FACILITY-associated health events — United States, 2005–2006. *MMWR Surveill Summ* 2008;57:1-38.

Note the need for larger feeders for waterpark type attractions as compared to FLAT WATER POOLS.

6.1.2.1.4.6 Chemical Safety

It is important that the operator be able to read chemical labels and material safety data sheets (MSDS). These include but are not limited to, NFPA 400 Oxidizer Hazard Classifications and STORAGE recommendations.

Reporting of POOL chemical-associated health events in the United States is not universally mandated, and no single surveillance system exists to characterize completely the number of exposures or associated injuries.

The National Electronic Injury Surveillance System (NEISS) and National Poison Data System (NPDS) data indicate that POOL chemical exposures and associated injuries are common. Data from NEISS show that inhalation of chemical fumes and splashing POOL chemicals into the eyes were the primary POOL chemical-associated injuries for which patients sought emergency treatment.

NPDS data reveal that nearly all single POOL chemical exposures likely were unintentional. Additionally, poor chemical handling and STORAGE practices at public AQUATIC FACILITIES, particularly those leading to mixing of incompatible chemicals, were the primary contributing factors of POOL chemical-associated health events reported in New York State.

Although no one data source alone clarifies completely the epidemiology of POOL chemical-associated injuries, together they reveal multiple commonalities that suggest these injuries are preventable. CDC recommendations⁴¹⁸ for preventing injuries associated with POOL chemicals were based on a review of the New York State health events and other government regulatory guidance.

These recommendations focus on improving facility design and engineering and education and training that stresses safe chemical handling and STORAGE practices and safe and preventive maintenance of equipment.⁴¹⁹

6.1.2.1.4.7 Entrapment Prevention

The Consumer Product Safety Commission (CPSC) reports injuries and fatalities regarding entrapment in residential and commercial POOL and SPA settings.⁴²⁰

6.1.2.1.5 Operations

OT

6.1.2.1.5.3 Aquatic Facility Types

⁴¹⁸ CDC. Healthy Swimming website. Recommendations for preventing pool chemical-associated injuries. Accessed 02/27/2011 at <http://www.cdc.gov/healthywater/swimming/pools/preventing-pool-chemical-injuries.html>

⁴¹⁹ Centers for Disease Control and Prevention. Pool chemical-associated health events in public and residential settings — United States, 1983-2007. MMWR Morb Mortal Wkly Rep. 2009;58(18):489-93.

⁴²⁰ Gipson K. Pool and spa submersion: estimated injuries and reported fatalities, 2010 Report. May 2010. Consumer Product Safety Commission. Accessed on 02/27/2011 at <http://www.cpsc.gov/library/foia/foia10/os/poolsub2010.pdf>.

Types of AQUATIC FACILITIES that are recommended to be discussed include POOLS, spray grounds/ interactive fountains, LAZY RIVERS, THERAPY POOLS, SPAS, WAVE POOLS, WATER SLIDES, competition POOLS, and WADING POOLS.

Settings of AQUATIC FACILITIES that are recommended to be discussed include community POOLS, apartment complex/condominium/ homeowners' association POOLS, hotel/motel POOLS, and water parks.

6.1.3 General Requirements for Training Courses

6.1.3.3 Course Length

OT

The MAHC intentionally does not prescribe a particular length of time for courses. Instead, the module is more PERFORMANCE-BASED by requiring that all of the essential topics in 6.1.2.1 be covered during the course. Most nationally recognized operator training courses run approximately 16 hours, and the MAHC technical committee assesses that it would be unlikely that all essential topics could be effectively taught in a shorter time period.

6.1.3.4 Instructor Requirements

OT

Recognized training on AQUATIC FACILITY operation and maintenance as well as instruction (without work experience) is sufficient to qualify an individual to be an instructor if the requirements in MAHC CODE Section 6.1.3.4 are met. It is, however, ideal to have both work experience and training in operation and instruction.

6.1.3.5 Final Exam

OT

The final exam is intended to assess the knowledge and skills of the POOL operator. Key components of the exam should include questions on the essential topics outlined in MAHC Section 6.1.2, performing essential calculations, reading meters and electronic equipment.

In the future it would be ideal if course final exams included more than just knowledge testing and have skills testing. This should include an on-site evaluation of skills such as proper calculations of gallonage and chemicals needed to be added to the AQUATIC FACILITY, how to operate the filtration/RECIRCULATION SYSTEM, including backwashing the filters, and water testing (chemical and physical parameters).

The Conference for Food Protection established Food Protection Managers Certification Program Standards⁴²¹. The MAHC will establish the Conference for the Model Aquatic Health Code, which in turn may establish Pool Operator Certification Program Standards. These STANDARDS will address issues such as examination development, test administration, and computer-based testing development and administration.

⁴²¹ Conference for Food Protection. Standards for Accreditation of food protection manager certification programs as amended by the 2010 biennial Conference for Food Protection (Reviewed April 2010 (8/5/2010). Accessed 02/27/2011 at <http://www.foodprotect.org/media/managercert/Standards%20April%202010%20corrected.pdf>

6.1.3.6 Course Certificates**OT**

The technical committee recommends that each certificate has a unique identifier to minimize the likelihood of mistaking the identity of certified operators.

At this time, certification process for QUALIFIED OPERATORS is not established. This may make it advisable for some group to develop a certification program similar to that of the Food Code. Thus, the Food Protection Managers Certification Program Standards, Section 7.7, "Responsibilities to the Public and to Employers of Certified Personnel" reflect the following, "A certification organization shall maintain a registry of individuals certified."

These STANDARDS reference certified food operators; however, the same STANDARD shall apply to operator training certificates. Thus, "any title or credential awarded by the course proved organization shall appropriately reflect the" AQUATIC FACILITY operator responsibilities and "shall not be confusing to employers, consumers, related professions, and/or interested parties."⁴²²

6.1.3.7 Continuing Education**OT**

It is recommended that a QUALIFIED OPERATOR continue their education by attending seminars or training courses to keep up-to-date in AQUATIC FACILITY operation and SAFETY.

In the long term, there is a need for development of system for Continuing Education Units. However, it may not be prudent to make the leap to require CEUs all at once, especially since this version of the MAHC will require for the first time that all AQUATIC FACILITIES have QUALIFIED OPERATORS. To have new requirements for operators at all AQUATIC FACILITIES and for CEUs may be overly burdensome at this time.

6.1.3.8 Certificate Renewal**OT**

Nationally recognized operator training courses require renewal of certificate. However, most professional certifications do not require retaking an entire course to renew certification, just passing an exam.

Most states require these certificates or copies to be readily accessible to the AHJ. Copies of certificates should be kept on file at the site and made available upon request. If photocopies are provided as proof of certificate, or certificate renewal, the original documents should be provided within 72 hours upon request from the AHJ.

6.1.3.9 Certificate Suspension and Revocation**OT**

The AHJ is expected to contact course providers with questions about the validity of any certificate or with questions about an operator's performance. In turn, course providers are expected to readily provide verification of certificates and suspensions and

⁴²² Conference for Food Protection. Standards for Accreditation of food protection manager certification programs as amended by the 2010 biennial Conference for Food Protection (Reviewed April 2010 (8/5/2010). Accessed 02/27/2011 at <http://www.foodprotect.org/media/managercert/Standards%20April%202010%20corrected.pdf>.

revocations of certificates and to notify the AHJ of actions taken in response to its reported concerns.

The Food Protection Managers Certification Program Standards, Section 7.5 reflect the following, “A certification organization shall have formal certification policies and operating procedures including the sanction or revocation of the certificate. These procedures shall incorporate due process.”⁴²³

6.1.3.10 Additional Training or Testing OT

Reasons for requiring such training or testing include but are not limited to operator performance or new developments in technology or operation. Such situations include but are not limited to repeat or serious violations identified on inspection, an investigation implicating operation as a contributing factor to illness or injury, or implementation of substantial rule changes. Training can range from brief dialogue during POOL inspection to full-day seminar for all operators in a jurisdiction. Testing can range from questions during inspection to paper- or computer-based exams.

6.1.3.11 Certificate Recognition OT

The technical committee aims to delegate authority to the AHJ both to choose to recognize individual certificates and to reverse its decisions if operators with certificates demonstrate inadequate knowledge or poor performance or due cause.

6.1.3.12 Course Recognition OT

The technical committee aims to delegate authority to the AHJ to choose to recognize operator training courses and to reverse its decisions if operators demonstrate inadequate knowledge or poor performance or due cause.

6.1.3.13 Length of Certificate Validity OT

A number of operator training course providers, including the American Swimming Pool & Spa Association, Aquatic Training Institute, National Swimming Pool Foundation, National Recreation and Park Association and YMCA, have set the maximum length of operator certificate validity and certificate renewal at 5 years.

6.2 Lifeguard Training

This portion of the MAHC deals directly with providing QUALIFIED LIFEGUARDS in an AQUATIC FACILITY to first, reduce the risk that could lead to injury and, secondly, appropriately respond to incidents when they happen. The duties of an AQUATIC FACILITY lifeguard have been compared to a number of other occupations including comparing the role of the police officer to that of a lifeguard at a swimming POOL.⁴²⁴ “The majority of the time, the task is very sedentary, sitting and watching. A quadriplegic could do it; until

⁴²³ Conference for Food Protection. Standards for Accreditation of food protection manager certification programs as amended by the 2010 biennial Conference for Food Protection (Reviewed April 2010 (8/5/2010). Accessed 02/27/2011 at

<http://www.foodprotect.org/media/managercert/Standards%20April%202010%20corrected.pdf>, page 27

⁴²⁴ Trotter A et al. Police health: a physician's guide for the assessment of police officers: 1994. Ottawa, Canada: Canadian Communication Group, 1993.

someone needs rescuing. Then the quadriplegic could not perform the required functions. It does not often happen to a lifeguard that someone needs rescuing, perhaps 0.1 per cent of the time. But the ability to jump into the water and save the drowning victim is critical to the job. This is the reason why there has been someone sitting and watching for the other 99.9 per cent of the time.” Bonneau and Brown’s⁴²⁵ position is that, because the disabled lifeguard is unable to perform the critical and essential part of the job, he is incapable of doing the job of lifeguard. Even if he can do 99.9 per cent of the job, he should not be employed as a lifeguard. The perception of the public is that all lifeguards can perform all that is critical and essential to their job set. Unfortunately this has sometimes been proven to be false.

Many drowning deaths resulted from omissions of basic SAFETY precautions^{426,427,428,429,430,431,432,433}. These include absent or inadequate POOL fencing, unattended young children at water sites, faulty POOL design resulting in victims becoming trapped below the surface of the water, poor POOL maintenance resulting in murky or cloudy water that obscured sight of submerged bodies, lifeguards being distracted by socializing with others and doing other chores such as manning admission booths and doing housekeeping chores while on lifeguard duty, and poorly trained lifeguards who did not recognize a person in trouble in the water or had not been properly trained in rescue and resuscitation techniques. In some cases, these are correctable issues that could prevent drowning deaths. We anticipate that if POOL and water SAFETY STANDARDS are strictly enforced, and as lifeguards continue to become better trained and adhere to important basic principles of surveillance, rescue, and resuscitation, the death rate in public AQUATIC FACILITIES should decline. The goal of this section is to give POOL owners and operators BEST PRACTICE guidelines for guarded and unguarded POOLS as tools to make AQUATIC FACILITIES safer for the general public.

6.2.1 Lifeguard Qualifications

Every day, about ten people die from unintentional drowning⁴³⁴. Of these, two are children aged 14 or younger. Drowning is the fifth leading cause of unintentional injury death for people of all ages, and the second leading cause of death for children ages 1 to 14 years⁴³⁵. From 2005-2009, there were on average 3,533 fatal unintentional

⁴²⁵ Bonneau J et al. Physical ability, fitness and police work. J Clin Forensic Med. 1995;2(3):157-64.

⁴²⁶ Modell JH. Prevention of needless deaths from drowning. South Med J. 2010 Jul;103(7):650-3.

⁴²⁷ Pelletier AR et al. Fatalities in swimming pools with lifeguards: USA, 2000-2008. Inj Prev. 2011 Aug;17(4):250-3.

⁴²⁸ Quan L et al. Ten-year study of pediatric drownings and near-drownings in King County, Washington: lessons in injury prevention. Pediatrics. 1989 Jun;83(6):1035-40.

⁴²⁹ Layon AJ et al. Drowning: Update 2009. Anesthesiology. 2009 Jun;110(6):1390-401.

⁴³⁰ Browne ML et al. Unintentional drownings among New York State residents, 1988-1994. Public Health Rep. 2003 Sep-Oct;118(5):448-58.

⁴³¹ Saluja G et al. Swimming pool drownings among US residents aged 5-24 years: understanding racial/ethnic disparities. Am J Public Health. 2006 Apr;96(4):728-33.

⁴³² Thompson DC et al. Pool fencing for preventing drowning in children. Cochrane Database Syst Rev. 2000;(2):CD001047.

⁴³³ Nichter MA et al. Profile of drowning victims in a coastal community. J Fla Med Assoc. 1989 Feb;76(2):253-6.

⁴³⁴ Centers for Disease Control and Prevention. Drowning 2005-2009. MMWR Morb Mortal Wkly Rep. 2012 May 18;61(19):344-7.

⁴³⁵ Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System (WISQARS) [online]. [cited 2012 May 3]. Available from: URL:

drowning (non-boating related) in the United States per year and more than one in five people who die from drowning are children 14 and younger⁴³⁶. More than 50% of drowning victims treated in emergency departments require hospitalization or transfer for higher levels of care (compared to a hospitalization rate of 6% for all unintentional injuries)^{437,438}.

Nonfatal drowning can cause brain damage that may result in long-term disabilities including memory problems, learning disabilities, and permanent loss of basic functioning (e.g., permanent vegetative state).^{439,440} Appropriately trained lifeguards are one way to reduce this risk at public AQUATIC VENUES.

6.2.1.1 Course Content

LG

This section defines a broad scope of lifeguard training which is further described in the section below. These topics are universally found in all currently recognized national lifeguard training programs

6.2.1.1.1 Hazard Identification and Injury Prevention

LG

Lifeguards have an obligation to know and understand common hazards associated with AQUATIC VENUES, and how they may be mitigated or prevented. A vital component of this obligation is to provide PATRON surveillance, commonly referred to as scanning. In order to prevent injuries, a lifeguard must be taught how to recognize various swimmer conditions that need intervention such as "active," "passive", and "distressed", and to use scanning strategies and techniques to be able to see and identify the emergency. This instruction is incomplete without also teaching lifeguards how to identify factors and circumstances which cause victim recognition to become impeded such as overcrowding, cloudiness of the water, glare, or obstacles on the DECK or in the water such as slides, inner tubes, or structures.

6.2.1.1.2 Emergency Response Skill Set

LG

Lifeguards should have a clear understanding of the responsibilities and actions of not only the physical skills, but the cognitive and decision making skills involved in an emergency response. Training agencies should develop appropriate skills to address the variety of water depths in which a victim may be found. These skills should be trained not only for the technical aspects of the skill, but also how the skill is incorporated into a venue's EMERGENCY ACTION PLAN. Lifeguards should be trained to respond within the scope of, at a minimum, Basic First Aid skills to provide care for illness or injury that may occur on land within the AQUATIC FACILITY until EMS arrives.

<http://www.cdc.gov/injury/wisqars>.

⁴³⁶ Centers for Disease Control and Prevention. Drowning 2005-2009. MMWR Morb Mortal Wkly Rep. 2012 May 18;61(19):344-7.

⁴³⁷ Centers for Disease Control and Prevention. Drowning 2005-2009. MMWR Morb Mortal Wkly Rep. 2012 May 18;61(19):344-7.

⁴³⁸ Centers for Disease Control and Prevention. Web-based Injury Statistics Query and Reporting System (WISQARS) [online]. [cited 2012 May 3]. Available from: URL: <http://www.cdc.gov/injury/wisqars>.

⁴³⁹ Cummings P et al. Trends in unintentional drowning: The role of alcohol and medical care. JAMA, 1999;281(23):2198-2202.

⁴⁴⁰ Spack L et al. Failure of aggressive therapy to alter outcomes in pediatric near-drowning. Pediatric Emergency Care 1997;13(2):98-102.

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6.2.1.1.3 CPR Skills**LG**

Lifeguards should be competent in CPR/AED at the professional rescuer level. The predominant body for the research of such skills is the International Liaison Commission on Resuscitation (ILCOR; www.ilcor.org). ILCOR currently reviews available research every 5 years and is composed of physicians and medical researchers from across the globe. One organization from each country/region of the world is assigned to interpret the science-based evidence and prepare guidelines for voluntary use by training agencies in that country/region. In the United States, this designated agency is the American Heart Association. The AHA collaborates with host groups, training agencies, as well as leaders in the field from nonprofit, educational and commercial organizations to create the “Guidelines for CPR and ECC”.⁴⁴¹ These recommendations are also commonly known as “AHA Guidelines”. Emergency Cardiovascular Care Update (ECCU; www.citizenpr.org) conferences are held biennially to present research and recommendations for guidelines. Detailed Information about the process and current research is available on the ILCOR and ECCU websites.

6.2.1.1.4 First Aid**LG**

The evidence-based application of first aid skills is currently reviewed through the National First Aid Science Advisory Board and recommendations published as a separate section of the AHA CPR and ECC Guidelines and are available at the website identified in MAHC Section 6.2.1.1.3.

6.2.1.1.5 Legal Issues**LG**

Lifeguards are part of the pre-hospital chain of response and should have basic understandings of critical legal concepts such as consent, refusal of care and negligence. Legal topics to be covered are not limited to these listed topics. Training agencies are strongly recommended to add topics based on the typical environment in which the trained lifeguard will be employed.

6.2.1.2 Lifeguard Training Delivery**LG****6.2.1.2.1 Standardized and Categorized****LG**

A standardized method of training with comprehensive materials is essential to the implementation of a consistently-delivered lifeguard training program.

A specific method is not being recommended by this Code.

6.2.1.2.2 Skills Practice**LG**

While much of the necessary cognitive knowledge may be obtained through self-directed study, especially in an interactive online format, physical skills practice is necessary to develop an understanding of how to apply knowledge and identify the various needs in an emergency situation. During skills practice an instructor can provide

⁴⁴¹ American Heart Association Guidelines available at :
http://www.heart.org/HEARTORG/CPRAndECC/Science/Guidelines_UCM_303151_SubHomePage.jsp/

individualized learning approaches, corrective feedback, and lead simulations and scenarios.

6.2.1.2.3 Shallow Water Training LG

It is important that the student lifeguard be able to practice and be tested in the deepest water specified in their certification.

6.2.1.2.4 Deep Water Training LG

It is important that the student lifeguard be able to practice and be tested in at least the minimum water depth specified in their certification.

6.2.1.2.5 Sufficient Time LG

This Code does not prescribe a particular length of time for courses. Instead, this Code is more performance based by requiring that all of the essential topics in MAHC Section 6.2.1.2 are covered by the training agency. National lifeguard training courses currently range from approximately 12 to 36 hours based on the type of training received for specific venues such as waterfronts or waterparks and the AHJ approval. Numerous factors make a uniform course length difficult to specify. Pre-existing knowledge, student to teacher ratio, internet-based learning formats, and course level are examples of these factors.

6.2.1.2.6 Certified Instructors LG

The instruction of a course by an individual not directly authorized by the training agency is extremely problematic and risks the quality controls established by the training agency. This also places public SAFETY at risk, in that the unauthorized instructor may not be fully qualified to teach the materials as intended. It also affects the training agency in that there is no direct recourse against an unauthorized, and unqualified, instructor. Lifeguard certifications, obtained from a lifeguard training course taught by an instructor who is not currently certified or authorized by the training agency to teach lifeguarding courses, will not be recognized as certified or trained by the AHJ per MAHC Section 6.2.1.3.

6.2.1.2.6.1 Minimum Prerequisites LG

The creation of minimum instructor prerequisites is a crucial piece to create quality and consistency for the training agency.

6.2.1.2.6.2 Completed Training LG

Although the code requires only completion of a lifeguard and lifeguard instructor training course as a prerequisite, an effective instructor understands the demands, stresses, and practical application of skills that can be gained from actual lifeguarding experience or the benefit of extensive training in an AQUATIC FACILITY environment. Instructors who lack such experiences may not fully understand the requirements and demands of a lifeguarding position and may not provide an experienced instructor's insight to students on how to apply the skills and knowledge found in the training agency curriculum.

It is necessary that lifeguard instructors have a firm understanding of the course they will be teaching. While it may be possible for an individual to pass a lifeguard instructor course without first taking a basic course, such an instructor would lack a firm understanding of the skills required by the training agency. It should be noted however, that training agencies should have the ability to create curriculum that would allow an individual from another training agency, or an individual who chooses to take an alternative to a full basic level course, to become instructors.

A Lifeguard Instructor Training Course must also provide information to the instructor candidates on how to safely and effectively conduct a course including:

- Knowledge of how to provide for the health and SAFETY of the students. (example knowing how to disinfect manikins for use),
- Ability to maintain adequate supervision at all times during in water skills and have a lifeguard on duty.
- Knowledge of how to effectively use program materials and training equipment as listed in MAHC Section 6.2.1.2.7.
- Ability to supervise student skill practice and provide timely, positive and corrective feedback.
- Knowledge and ability to evaluate students as to meeting the criteria set forth by the training agency for which they are an instructor.

6.2.1.2.6.3 Instructor Renewal/Recertification Process LG

The training agency must have a process in place for renewal/recertification of instructors. The process should identify the criteria when reauthorization is required such as an instructor must teach a certain number of lifeguard courses in a certain time period (years) and/or do in-person or on-line updates as needed (e.g., when course materials or content have been revised).

6.2.1.2.6.4 Quality Control LG

Quality instruction is crucial to the survival of a training agency and, in the case of lifeguard training, crucial to the SAFETY and well-being of millions of swimmers every year. Training agencies must have procedures that allow for the correction, remediation and, if necessary, the revocation of instructor credentials.

6.2.1.2.7 Training Equipment LG

These pieces of equipment are required to accomplish the objectives of lifeguard training as outlined in the code. It is educationally sound to provide enough equipment based on the number of students who will be using it at the same time. Below is a listing of ratios recommended by several agencies; however, the training agency can adjust ratios based on their own delivery method.

American Heart Association

- Adult, child, and infant CPR training manikins, 1 manikin per 3 students per class period,
- CPR masks-- 1 per 3 students,

- Valves for CPR masks - 1 per student,
- AED trainers -- 1 per 3 students,
- Bag-valve-mask resuscitators -- 1 per 3 students, and
- Manikin cleaning supplies, -- as needed between students and after class

American Safety & Health Institute

Recommended student to equipment ratio: 3 to 1

American Red Cross

- Rescue tubes (one for every two participants),
- Adult and infant manikins (one of each for every two participants),
- Adult and pediatric bag-valve-mask resuscitators,
- AED training devices (one for every two participants),
- Adult AED training pads (one set for each training device),
- Pediatric AED training pads (one set for each training device),
- External bleeding control materials for each pair of participants,
 - Including two 3-inch roller bandages and,
 - four non-sterile dressings or gauze pads,
- Splinting materials for each pair of participants,
 - including four triangular bandages,
 - one 3-inch roller bandage,
 - a blanket or pillow, and
- a rigid splint such as a magazine, cardboard, or long and short boards;
- Spinal immobilization materials,
- Backboards, each equipped with 3 straps and head immobilizers (one backboard for every three participants is recommended); if fewer backboards are available, additional time may be required.

6.2.1.3 Competency and Certification LG

6.2.1.3.1 Proficiency LG

6.2.1.3.2 Requirements LG

The readiness of lifeguard candidates to respond to aquatic-based emergencies should be assessed thoroughly for skill mastery, knowledge, and practical application prior to being issued a certificate. In regards to a written exam, all nationally recognized training agencies currently require an 80% correct answer rate as the minimum threshold for passing.

6.2.1.3.3 Instructor Physically Present LG

The physical presence of the instructor of record assures that students are evaluated accordingly in both cognitive and physical testing. This also significantly reduces the risk of individuals becoming certified who lack the basic skills and knowledge necessary through either acts of omission caused by the substitution of another individual to provide testing, or by student fraud.

6.2.1.3.4 Certifications**LG**

A certification issued at the end of a lifeguard course indicates that the individual successfully met the training requirements on the day of assessment. A completion certificate does not imply future performance or suitability in all circumstances. It is the responsibility of the employer to verify skills and ongoing competency suitable for the environment in which the lifeguard will be assigned through pre-service and in-service training.

6.2.1.3.5 Number of Years**LG**

The United States Lifeguarding Standards Coalition (USLSC) final report⁴⁴², the scientific review by the American Red Cross⁴⁴³, and the technical committee agree that lifeguarding skills need to be refreshed as often as possible. The ARC reviewed 12 peer-reviewed publications on CPR skill retention in healthcare providers (retraining intervals of 6 weeks to 24 months) and 28 papers focused on non-healthcare providers (retraining interval of 3 to 48 months).⁴⁴⁴ The data from these 40 studies (all measured manikin skills, none measured patient outcomes) showed significant CPR skill degradation within the first year after training in both job categories and the majority of skill degradation occurred in the first year. None of the 40 studies documented adequate skill retention after two years but several showed improved retention if a brief refresher was given at 6-12 months. As a result of this review and the low probability that lifeguards use the skill often enough in their job to retain the skill, the Technical Committee felt that the skills needed to be refreshed every year through re-certification. They did not think that the convenience of aligning the length of valid certifications for lifeguarding and first aid at 2 years overrode the strong data showing CPR skill degradation over two years that could put BATHER health at risk. The time periods listed in this Code are acceptable only if ongoing in-service and pre-service STANDARDS are followed.

6.2.1.3.6 Documentation**LG**

In order to verify compliance with MAHC Section 6.2.1.3.5, requiring the expiration date of the certification allows employers and the AHJ to identify that the lifeguard has a current certification.

Providing the level of training gives guidance for the employer or AHJ for suitability in specific AQUATIC VENUES. Examples of level of training include: Lifeguard, Waterpark Lifeguard, Waterfront Lifeguard, and Shallow Water Lifeguard. Such descriptions are not necessarily universal among all current training agencies.

The ability to identify the lifeguard instructor allows for higher quality control by the training agency. It also aids in the prevention of fraudulent certifications.

⁴⁴² United States Lifeguard Standards Coalition. United States Lifeguard Standards: An Evidence-Based Review and Report. Int J Aquatic Res Edu. 2011;5(1):61-129.

⁴⁴³ American Red Cross. ACFASP Scientific Review. CPR Skill Retention review. Accessed at <http://www.instructorcorner.org/media/resources/SAC/Reviews/CPR%20Skill%20Retention.pdf>

⁴⁴⁴ American Red Cross. ACFASP Scientific Review. CPR Skill Retention review. Accessed at <http://www.instructorcorner.org/media/resources/SAC/Reviews/CPR%20Skill%20Retention.pdf>

Clearly stating the restrictions on water depth for which the lifeguard is qualified allows the employer and the AHJ to quickly ascertain the basic abilities of the lifeguard that were assessed during training.

6.2.1.3.7 Expired Certificate **LG**

6.2.1.3.7.1 Challenge Program **LG**

A challenge course is one in which a lifeguard demonstrates the essential skills and knowledge required by the training agency. This demonstration is performed without prior review and/or instruction at the time of the challenge by the instructor. Prompting or coaching is not performed unless necessary to adequately assess skill level (i.e. “the victim is not breathing”).

6.2.1.3.7.2 Certificate Renewal **LG**

A renewal course can also be described as a recertification course. Review / Recertification courses are abbreviated courses designed to be used to assess that a currently certified lifeguard has the necessary skills and knowledge to perform essential competencies required of the training agency.

Although some skills and information are universal to all lifeguard training agencies, there are differences in physical skills. A lifeguard attempting to recertify through a different agency is not likely to have ample time to master these different physical skills. This should not be confused with “crossover” type courses which are specifically designed to teach a currently certified lifeguard the different skills and information from another training agency.

6.2.2 Aquatic Supervisor Training

6.2.2.1 Lifeguard Supervisor Candidate Prerequisites **LG**

The Technical Committee agreed that 18 and above was an adequate age level to consider a person as being mature enough for this position but there are many examples of good supervising at a younger age. This was a starting point but many other factors with regard to experience, training, management skills and others were equally or more important. For this reason, the minimum age for a LIFEGUARD SUPERVISOR is not specified and is limited to meeting the minimum age requirement of a lifeguard and having the experience that equates to one season of lifeguarding (3 months).

The requirement of the ability to communicate in English is related to the ability to effectively activate the EMERGENCY ACTION PLAN and deliver instructions as well as interface with emergency services. This is similar to the requirement on airlines for emergency exit row seating.

6.2.2.2 Lifeguard Supervisor Training Elements **LG**

As of the writing of this Code, lifeguard supervision and management training courses are limited. In the development of this Code, the Technical Committee recognizes the

importance of ongoing AQUATIC VENUE supervision with adequate training in injury prevention and response. What constitutes supervisor and management training was heavily discussed. The concept of “supervisor training” lends itself to far more than simply MONITORING lifeguards and performing essential functions of the lifeguard as needed. Required skills for the supervisor include staff management skills, emergency response, decision making, knowledge of aquatic industry STANDARDS, etc. This list is obviously not comprehensive. This leads to a main concern in the development of a LIFEGUARD SUPERVISOR course which is course content and length. Training agencies are encouraged to develop a system of training LIFEGUARD SUPERVISORS that incorporates the critical components of supervising lifeguards and responding to incidents in an AQUATIC FACILITY as these items directly affect BATHER SAFETY. This may include a variety of levels that address this information in various ways and as appropriate for the intended audience of each level course. The skills and knowledge found in this section are considered by the Technical Committee to be essential to any LIFEGUARD SUPERVISOR training course, regardless of intended depth of scope. The course outline and requirements mirror that of the lifeguard training course requirements.

LIFEGUARD SUPERVISORS need to have knowledge beyond that of the lifeguard training program. The LIFEGUARD SUPERVISOR is responsible for keeping the lifeguard accountable for their own performance and as such should be MONITORING scanning and vigilance within the zone of PATRON responsibility. As situations occur, the LIFEGUARD SUPERVISOR will also need to react to reduce risk while they understand the legal responsibilities of the job.

Due to the nature of the content in the LIFEGUARD SUPERVISOR Training, it is possible for this content to be delivered in person or online utilizing various methods such as video and interactive media to establish competency.

6.2.2.3 Lifeguard Supervisor Training Delivery LG

6.2.2.3.1 Standardized and Comprehensive LG

The term standardized is meant to convey that the materials are STANDARD, in writing, and are consistent from one course to another when delivered. This would require that providers, whether an agency or an AQUATIC FACILITY, have a STANDARD method to deliver the course.

6.2.2.3.2 Sufficient Time LG

A course length is not specified as each training agency may have their own program that incorporates all the requirements but may also add other topics. The method used to effectively instruct is up to the training agency. Some may take more time than others. The code is not prescriptive on timing but rather on a course timeline that allows for covering the course content.

6.2.2.3.3 Certified Instructors LG

This is the same rationale as for lifeguard training.

This allows for an AQUATIC FACILITY to have its own internal LIFEGUARD SUPERVISOR training course or use a training course through a training agency.

6.2.2.3.3.1**Minimum Prerequisites****LG**

This allows for experienced supervisors that may not have the physical skills to do the current lifeguard course as defined by the MAHC but still require the knowledge of lifeguarding.

The LIFEGUARD SUPERVISOR instructor training course utilizes the same rationale as the Lifeguard Instructor training course.

6.2.2.3.3.2**Quality Control****LG**

This is the same rationale as for lifeguard training.

6.2.2.4**Competency and Certification****LG****6.2.2.4.1****Lifeguard Supervisor Proficiency****LG**

LIFEGUARD SUPERVISOR testing could be in many forms from situational-based observations, shadowing with an experienced supervisor, or testing technical knowledge. Some LIFEGUARD SUPERVISOR skill proficiencies can be subjective so the methodology for testing is not prescribed in the code.

6.2.2.4.2**Lifeguard Supervisor Certifications****LG**

This uses the same rationale as for the lifeguard instructor training course found in MAHC Section 6.2.2.3.3.1.

6.3 Facility Staffing**6.3.1****Operators Requirements and Availability****6.3.2****Facilities Requiring Lifeguards**

There are many conditions that result in higher risk for BATHERS in an AQUATIC FACILITY and/or higher risk for any persons attempting to assist a BATHER in distress. These conditions each have their own distinct features that the Committee felt a QUALIFIED LIFEGUARD presence would reduce those risks. These requirements only apply to AQUATIC VENUES with standing water.

- 1) The 50th percentile adult is at least 64 inches (1.6 m) tall. The rationale is that the average adult BATHER's head would be above the static water line and they could use the AQUATIC VENUE without difficulty. If a BATHER were in distress, another adult BATHER would be able to assist with equipment or without equipment. Under these conditions assuming adults are present, the likelihood of providing assistance by untrained persons is high compared to water depths above 5 feet (1.5 m).

The Technical Committee thinks it necessary to begin working to prevent some

of the deaths caused by greater water depth combined with the lack of lifeguard supervision. The hardship this could cause unguarded AQUATIC FACILITIES is recognized. As a result, the MAHC requirements still allow for existing AQUATIC FACILITIES to be unguarded if they follow the requirements outlines in the MAHC such as required signage. However, new construction of unguarded AQUATIC VENUES will require them to be less than 5 ft (1.5 m) deep.

- 2) Many STANDARDS recognize that a person who is under the age of 14 is considered to be a child and that their ability to make decisions especially when complying with rules will need adult supervision⁴⁴⁵. Because the AQUATIC VENUE presents the risk of drowning at any depth and despite rules being posted, adult supervision is required for compliance with those rules.

The 50th percentile female at age 14 is 64 inches (1.6m) tall while the 50th percentile female at age 13 is less than 62 inches (1.6 m) tall. This is a critical time frame in which the 2+ inches (5.1 cm) are the difference between water over one's nose/mouth or the ability to keep the nose/mouth above the static water line.⁴⁴⁶

The phrase "allows for unsupervised children" implies that an AQUATIC FACILITY that does not allow unsupervised children would not need a QUALIFIED LIFEGUARD. The intent for supervision of children is that parents/guardians or other similar adults responsible for the children are present at poolside with the children and the children are in sight. The critical component is how this is enforced. In some cases, the facility may have a sign posted that persons under the age of 14 are not allowed, such as a hotel POOL. In these cases, mechanisms should be in place for MONITORING and enforcing the rule understanding that by posting a sign, it is the responsibility of the adult supervising these persons under 14 to also comply with the rule.

- 3) The responsibilities of a QUALIFIED LIFEGUARD are different from the responsibilities of the chaperone of youth group. The MONITORING of children in these environments is often more than six children to every chaperone. These responsibilities must be separated by having the presence of a QUALIFIED LIFEGUARD that is not distracted by the activities of the group and is focused on their zone of PATRON surveillance.

The chaperone, even if trained as a lifeguard, cannot manage both PATRON surveillance and the activities of individual children. If the chaperone is not trained as a lifeguard, it puts them at risk if a rescue is required.

- 4) Competitive swimming, sports, lifeguard training, exercise programs, and group swimming lessons all include multiple persons being instructed by one or more

⁴⁴⁵ International Standards Organization. ISO/IEC Guide 50:2002. Safety Aspects --Guidelines for Child Safety. Available at http://www.iso.org/iso/catalogue/catalogue_tc/catalogue_detail.htm?csnumber=32941

⁴⁴⁶ CDC. Growth chart for girls age 2-20. (2000). Accessed 2014 Feb 6 at: <http://www.cdc.gov/growthcharts/data/set1clinical/cj41c022.pdf>

persons for a distinctly different objective. The primary focus is on the activity and not on PATRON surveillance. Similar to the rationale for youth groups, there is a need to separate the responsibility of the coach/instructor from that of providing dedicated PATRON surveillance.

Group swim lessons are an obvious reason to have a QUALIFIED LIFEGUARD as participants are not proficient at swimming, thus a higher risk for drowning. Lifeguard training, sports, exercise programs, and competitive swimming involve exertion and could result in a BATHER in distress. If the instructor is focused on an individual, the risk of a different person drowning unnoticed is higher than if a QUALIFIED LIFEGUARD was assigned just to PATRON surveillance.

- 5) Aquatic rescue throwing devices have been found to have a reasonable ability to reach 30 feet (9.14 m) in distance or less by untrained individuals. AQUATIC VENUES with distances greater than what it is reasonable for SAFETY equipment to be used from the DECK need to be supervised with QUALIFIED LIFEGUARDS.
- 6) Anywhere there is moving water there is a greater chance for a PATRON to be moved by the force of the water in an unwanted manner. This could include moving the PATRON a distance from SAFETY, causing the PATRON to lose their balance and have a sudden submersion, and other disruptive problems. This is not intended to include "normal" flow from filtration system wall INLETS. The Technical Committee agrees these AQUATIC VENUES need to have QUALIFIED LIFEGUARD supervision.

Waterslide CATCH POOLS have an induced current from the lift pump providing water as lubrication on the slide. This is not to be confused with dry slides that are on a POOL DECK and do not have water flowing down them. Some smaller slides have a small amount of water on them to lubricate the surface but generally do not have a dedicated POOL to "catch" riders and do not generate a significant current.

INTERACTIVE WATER AQUATIC VENUES that do not include standing water are not included in this line item as they have an induced water movement but do not have standing water. There is no QUALIFIED LIFEGUARD requirement for an AQUATIC VENUE with no standing water.

- 7) The risk of spinal injuries increases with activities involving head first entries from starting platforms and diving boards. As such, the need for QUALIFIED LIFEGUARDS to monitor behaviors and control the use of starting platforms and diving boards is important.

6.3.3 Safety Plan

The Technical Committee agreed that there needs to be a SAFETY PLAN that is specific to the AQUATIC FACILITY. Training agencies, ANSI/APSP - 1 and - 9 STANDARDS for public swimming POOLS and aquatic recreation facilities all speak to having plans written, rehearsed and reviewed. The Technical Committee agreed that there are other types of

plans that detail processes that directly affect PATRON SAFETY. In the code, the SAFETY PLAN is outlined to contain several PATRON-SAFETY components. The SAFETY PLAN is written dependent on whether or not QUALIFIED LIFEGUARDS are present. The reader will note that the SAFETY PLAN components are different for guarded and unguarded AQUATIC FACILITIES.

The facility staffing plan is meant to identify positions in the AQUATIC FACILITY that address specific risks as well as support staff that would be present to assist in cases of emergency or provide support by MONITORING performance of QUALIFIED LIFEGUARDS (for AQUATIC FACILITIES requiring them). In unguarded AQUATIC FACILITIES, this plan would include other staff in the STAFFING PLAN. Training agencies, ANSI standards for public swimming POOLS and AQUATIC FACILITIES all speak to having plans written, rehearsed and reviewed for emergency action.

Pre-employment testing as well as scheduled training is needed to verify that staff members are qualified for the environment. The committee agreed that ongoing in-service training programs for lifeguards, attendants, POOL operators, and other aquatic personnel should be required. To address this, the definition for QUALIFIED LIFEGUARD requires ongoing in-service training. Such programs should include drills aimed at raising the awareness of AQUATIC FACILITY surveillance, victim recognition, emergency response, CPR/water drills, and simulations incorporating daily challenges. In addition, in-service training needs to be documented.

6.3.3.1 Code Compliance Staff Plan

LG

In consideration of the requirements of the code as it relates to staff, the Technical Committee recognizes the need for identifying an individual or individuals to be responsible for compliance with the code and the general operation of the AQUATIC FACILITY. For this reason, certain functions are identified and the AQUATIC FACILITY should designate persons to be responsible for each function even if multiple functions are accomplished by a single person. The AQUATIC FACILITY staffing plan is meant to identify risks and create accountability for the prevention and/or mitigation of such risks by identifying person(s) responsible for each.

Risk Management:

It is important to not only address identified risks but to designate persons who shall be responsible for conducting periodic safety inspections to be proactive about finding and mitigating risk as well as making decisions on closure for imminent hazards. Determining who is responsible for deciding on closure of the aquatic facility is important as it empowers the designated person but also creates a clear point-person for staff to go to for making this decision. The AHJ may be conducting periodic reviews and may have recommendations or need additional information. It would be beneficial to identify the individual or position responsible for interfacing with the AHJ to most effectively address changes or to provide background information. This makes it clear to stakeholders where to direct information or requests.

Maintenance and Repair:

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Once risks are identified, it is critical to determine who is responsible for mitigating those risks. In some cases, it may be a facility maintenance person responsible for conducting repairs, but ultimately it is the responsibility of management to make sure these risks are addressed. Failure to maintain water and air quality can result in illness and it is the responsibility of the aquatic facility to maintain proper air and water quality. In some cases, a maintenance team manages these systems and in some cases it may be a third party contractor or the qualified lifeguard staff. Nonetheless it is important to determine who is responsible for these systems to minimize the risk to BATHERS.

Enforcing Rules and Responding to Emergencies:

It is important to identify who is responsible for rule enforcement. One may assume the QUALIFIED LIFEGUARD is the person responsible for rule enforcement, but by identifying the function here, it will make it clear that their primary role is in preventing injury. QUALIFIED LIFEGUARDS will generally be the first responder to an incident but other support staff may be participating in the emergency action plan, whether qualified lifeguards are present or not. Identifying qualified lifeguards, lifeguard supervisors, medical specialists, and management are critical pieces of an emergency action plan and should be identified as a part of the staffing plan in any Safety Plan.

Supervising Staff:

It is important to have a person designated as the person responsible for the critical safety functions of an aquatic facility. Although each QUALIFIED LIFEGUARD is accountable for their zone, the lifeguard supervisor makes sure each individual is doing what is expected and is present for responding to emergencies and taking the lead in making decisions about imminent hazards. Accountability for rotations and breaks lies with the lifeguard supervisor and should be clearly identified in the safety plan to show the ability to comply with the code.

Training:

QUALIFIED LIFEGUARDS who cannot demonstrate proficiency in their lifeguarding skills may be a danger to the BATHERS and to themselves. Serious deficiencies that are not immediately corrected may cause the serious injury or death of a BATHER, the qualified lifeguard, or other staff member. For this reason, it is important to identify who is responsible for conducting pre-service evaluations and in-service training. In both cases, it may be someone specifically trained in evaluating skills or trained in training others.

6.3.3.1.1 Zone of Patron Surveillance

LG

The zones of PATRON surveillance are identified in the SAFETY PLAN so that all stakeholders are aware of the zones, how many QUALIFIED LIFEGUARDS are required to effectively cover all parts of the AQUATIC VENUE(S), and show that each zone can be effectively monitored by a QUALIFIED LIFEGUARD in accordance with the code.

The Technical Committee agreed that having identified zones of PATRON surveillance was one of the most needed components for all AQUATIC VENUES. QUALIFIED LIFEGUARDS should be able to determine their area of responsibility and be able to focus on that

area. With the proper coverage, all areas of the AQUATIC VENUE needing to be covered would be assigned. The Technical Committee thought that one of the challenges in AQUATIC VENUE management is to ensure that QUALIFIED LIFEGUARDS understand the exact scope of their zone of PATRON surveillance. Training agencies and the ANSI STANDARDS for AQUATIC FACILITIES speak to “lifeguards understanding their responsibilities to their assigned stations.” This would include understanding what type of position (e.g., elevated, roaming) the QUALIFIED LIFEGUARD should be in for the most effective PATRON surveillance.

Both the ANSI/APSP-1 Public Swimming Pools and ANSI/APSP-9 standards state that the lifeguard “shall be positioned and provided equipment in order to reach the victim within 20 seconds of identification of a trauma or incident (e.g., response time).”

For the purposes of maintaining effective surveillance of a zone of PATRON responsibility, the zone is generally set up based on the location of the QUALIFIED LIFEGUARD and their ability to see the entire zone. In some cases, it is required the QUALIFIED LIFEGUARD roam to see the entire zone and in some cases the QUALIFIED LIFEGUARD must be elevated to see the whole zone. For this reason, the SAFETY PLAN must stipulate by what method the QUALIFIED LIFEGUARD can see the whole zone.

Additional responsibilities may include MONITORING of adjacent DECKS or MONITORING activities on a structure such as a waterslide, play element, or other AQUATIC FEATURE. As the aquatics industry has added other AQUATIC FEATURES to traditional AQUATIC VENUES, it is important to identify these additional responsibilities that may not be apparent if the zone were strictly a flat-water POOL.

An AQUATIC FACILITY may have more than one AQUATIC VENUE and for each AQUATIC VENUE, may have multiple zones of PATRON responsibility. These zones may overlap in some areas and it is important to show there are not unassigned areas. The Code does not speak to a time STANDARD for identification of an incident versus the response time, as there are too many variables in the circumstances leading to an incident.

6.3.3.1.2 Rotation Procedures

LG

Studies have documented the effect of critical and non-critical signals on maintaining vigilance in tasks; these may be useful in understanding lifeguarding duties. Jerison and Pickett demonstrated that a high number of critical signals could be processed by the lifeguard for up to 60 minutes with tolerable effects on vigilance.⁴⁴⁷ However, the study found that low numbers of critical signals indicated that detrimental effects on vigilance occurred after only 20 minutes. This study also referenced the Mackworth Clock Test, commissioned in 1950 by the British Royal Navy, which found that optimal vigilance cannot be maintained for more than 30 minutes.⁴⁴⁸ Researcher N.H. Mackworth developed the visual sensitivity loss model. Using classic clock-task experiments, signal detection performance often declined during the first half hour of the watch. Later

⁴⁴⁷ Jerison HJ, Pickett RM. Vigilance: The Importance of the Elicited Observing Rate. *Science*. 1964;143(3609):970-1.

⁴⁴⁸ Mackworth NH. Researches in the measurement of human performance. MRC spec. Report 268 HMSO, 1950.

experiments found five- to 10-minute breaks reset the vigilance level to its original point.⁴⁴⁹

The SAFETY PLAN should specify how breaks will be instituted into the rotation plan without reducing the number of QUALIFIED LIFEGUARDS ON PATRON surveillance.

For single QUALIFIED LIFEGUARD AQUATIC FACILITIES, the plan needs to address procedures for keeping PATRONS out of the water while the QUALIFIED LIFEGUARD is on break or performing other alternation of task activities. Other AQUATIC FACILITY staff may need to be at POOLside to ensure that PATRONS stay out of the water, unless all PATRONS leave the AQUATIC VENUE and it is appropriately secured against entry. The "off-duty" QUALIFIED LIFEGUARD cannot be responsible for this activity as it does not meet the intent, which is to accomplish a reset of the vigilance level.

Having a sound lifeguard rotation plan and procedures is crucial to the ability of the QUALIFIED LIFEGUARDS to be effective in PATRON surveillance. During the rotation of QUALIFIED LIFEGUARDS there can potentially be a lapse of PATRON surveillance if not done correctly. Because of this, the rotation system must be practiced and evaluated as to eliminate or minimize the lapse of PATRON surveillance time.

Heat, humidity, and high BATHER LOADS are stresses for QUALIFIED LIFEGUARDS, which may warrant more frequent breaks.

6.3.3.2 Emergency Action Plan

LG

The Committee agreed that there needs to be an emergency closure policy that is retained and available for review by the AHJ.

Training agencies educate lifeguards to expect a written EMERGENCY ACTION PLAN created by the AQUATIC FACILITY where they will work that addresses the reasonably foreseeable emergencies that could occur.

There is a need to identify how emergencies are communicated within the AQUATIC FACILITY and external to the AQUATIC FACILITY. The types of emergencies that could occur in AQUATIC FACILITIES include but are not limited to: chemical spills, submersion events/drowning, fire, violent acts, lost children, contamination (fecal incidents and water clarity), and inclement weather.

AQUATIC FACILITY staff will likely be the persons to observe any imminent hazards and should be empowered to close POOLS or other areas of the AQUATIC FACILITY should those hazards be present. In particular, fecal incidents, water clarity, and inclement weather may be encountered more often and the AQUATIC FACILITY staff should know procedures for dealing with those imminent hazards and their authority to close the AQUATIC FACILITY.

⁴⁴⁹ Lichstein KL, Riedel BW, Richman SL. The Mackworth Clock Test: a computerized version. J Psychol. 2000 Mar;134(2):153-61.

6.3.3.2.1 Coordination of Response**LG**

The EMERGENCY ACTION PLAN identifies the individuals available and expected to respond. The goal of an EAP for a life-threatening emergency should be to activate EMS and provide for other individuals to assist the QUALIFIED LIFEGUARD with the actions identified in the EAP (such as CPR if needed) as soon as possible. Performing effective compressions is difficult to maintain for more than a few minutes, and the presence of at least one person to take over compressions creates a cycle of rest.

In AQUATIC FACILITIES where there are multiple QUALIFIED LIFEGUARDS and/or other staff persons such as desk or maintenance personnel who are always closely available when the AQUATIC FACILITY is open, it is feasible for many persons who are trained in CPR/AED and first aid to respond within 3 minutes. Having a person who is CPR trained that can respond within minutes greatly improves survivability.⁴⁵⁰

At a single QUALIFIED LIFEGUARD AQUATIC FACILITY, the SAFETY PLAN should identify the options for obtaining assistance, which is likely to include use of bystanders. If bystanders are part of the EAP, pre-service and in-service training should include how to direct bystanders in an emergency.

6.3.3.3 Pre-Service Requirements**LG****6.3.3.3.1 Safety Team EAP Training****LG**

The Technical Committee agreed that there needs to be an SAFETY PLAN that is specific to each AQUATIC VENUE. Training agencies, ANSI standards for public swimming POOLS and AQUATIC FACILITIES all speak to having plans written, rehearsed and reviewed for emergency action.

It is imperative that EMERGENCY ACTION PLAN training take place before the staff begins their work as an emergency can happen at any time.

Providing a copy or posting a copy to staff ensures staff has access to the information at any time.

6.3.3.3.2 Safety Team Skills Proficiency**LG**

Responding to emergencies may require more specific skills and physical abilities, which once learned, must be maintained as emergencies can occur at any time. This demonstration of skill and/or knowledge verifies the staff person is ready to fulfill their role.

6.3.3.3.3 Qualified Lifeguard EAP Training**LG**

The QUALIFIED OPERATOR is required to prepare the SAFETY PLAN as a set of policies for the AQUATIC FACILITY. It is imperative that the employees be aware of their responsibilities and have access to the information at all times the AQUATIC FACILITY is

⁴⁵⁰ Ritter G et al. The effect of bystander CPR on survival of out-of-hospital cardiac arrest victims. Am Heart J. 1985 Nov;110(5):932-7.

open so they may refresh their memory or seek further information. Training during pre-service will allow the QUALIFIED LIFEGUARD to become trained in the SAFETY PLAN of the AQUATIC FACILITY.

6.3.3.3.4 Qualified Lifeguard Skills Proficiency LG

It is imperative that all lifeguards hired are currently able to perform effectively in the workplace. AQUATIC FACILITIES need to assess the lifeguard's ability to perform the job skills necessary to be a QUALIFIED LIFEGUARD at the AQUATIC FACILITY including at any AQUATIC VENUES within the AQUATIC FACILITY where the lifeguard may be assigned before allowing the lifeguard to be on duty.

When first hired, lifeguarding skills should be assessed during pre-service training prior to the first duty assignment. In-service training should assess skills on a regular basis to determine ability for ongoing duty assignments. Training agencies require that employees have training, knowledge and the proper equipment to protect the employee and the PATRON against disease transmission. This level of awareness must be in place before active PATRON surveillance takes place.

All lifeguard training agencies require lifeguards to be able to perform a combined rescue skill with equipment to receive completion certification. All lifeguard training agencies train their lifeguards that they must be able and ready to recognize, respond, rescue, and resuscitate a victim as quickly as possible. The employer should verify that the lifeguard maintains these skills in the workplace.

6.3.3.3.5 CPR/AED and First Aid Certificate LG

6.3.3.3.6 Documentation of Pre-Service Training LG

Documentation provides a method for the AHJ to verify compliance. An example of the type of documentation required is a skills check-off form with a participant attendance sheet.

6.3.3.4 In-Service Training LG

6.3.3.4.1 Documentation of In-Service Training LG

All lifeguard training agencies support the need for ongoing in-service training. Both ANSI/APSP -1 and -9 state that certain topics be covered in this training. These in-service trainings should include all the SAFETY PLANS and in and out of water rescue skills for lifeguards. Documentation is crucial to prove that the in-service training took place, identifies the topics covered, documents who was in attendance, and the date and time of the training.

The United States Lifeguarding Standards Coalition final report⁴⁵¹, the scientific review by the American Red Cross⁴⁵² and the Technical Committee agree that lifeguarding

⁴⁵¹ United States Lifeguard Standards Coalition. United States Lifeguard Standards: An Evidence-Based Review and Report. Int J Aquatic Res Edu. 2011;5(1):61-129.

⁴⁵² American Red Cross. CPR Retention review. Accessed at

skills need to be refreshed as often as possible. The Texas state POOL code requires at least 4 hours of in-service a month. Other states require that in-service training be documented and signed. The Committee agrees that all AQUATIC FACILITIES should have an ongoing in-service program for their SAFETY TEAM members.

The term “periodic” is to offer flexibility to the QUALIFIED OPERATOR based on their seasonality, staff scheduling, and the training agency requirements.

6.3.3.4.2 In-Service Documentation

LG

Documentation is maintained at the AQUATIC FACILITY to provide a method for the AHJ to verify compliance during an inspection.

6.3.3.4.3 In-Service Training Plan

LG

Requiring QUALIFIED LIFEGUARDS to have the ability to respond to a victim and complete a rescue is critical. To not specify this requirement would allow a QUALIFIED LIFEGUARD to demonstrate the individual skills but not necessarily have the ability to do all the skills in consecutive order to complete the whole rescue.

Physical fitness is a critical part of performance when conducting a rescue. QUALIFIED LIFEGUARDS who are newly certified must maintain their physical fitness and skill proficiency throughout the term of their certificate as those skills can be called upon at any time. The required level of physical fitness can be determined by several means.

Schultz and colleagues showed that in order to do CPR at 80 compressions a minute (training now requires 100 compressions a minute) over a 10 minute period of time the METS (metabolic equivalents) required to perform this task was 4.6 ± 0.7 ⁴⁵³. One would expect this number to increase using the current protocol for CPR. The following logic and calculations was developed by Dr. Timothy Lightfoot⁴⁵⁴ using METS values for a variety of activities that lifeguards might be expected to perform.^{455,456,457} If someone swims 500 yards (457 m) in 10 minutes, they exert 8 METs/min (so, almost double the CPR cost discussed above); Similar levels of exertion are given by:

- Running at 5 mph on a level grade (running 1 mile in 12 min or 0.8 mile in 10 minutes)
- Riding a bicycle at 14 mph on level grade (riding 2.3 miles in 10 minutes)

<http://www.instructorscorner.org/media/resources/SAC/Reviews/CPR%20Skill%20Retention.pdf>

⁴⁵³ Shultz JJ, et al. Comparison of exertion required to perform standard and active compression-decompression cardiopulmonary resuscitation. Resuscitation. 1995 Feb;29(1):23-31.

⁴⁵⁴ Dept. of Health and Kinesiology. Texas A&M University. College Station, TX 77845-4243.

⁴⁵⁵ Ainsworth BE et al. 2011 Compendium of Physical Activities: a second update of codes and MET values. Med Sci Sports Exerc. 2011 Aug;43(8):1575-81.

⁴⁵⁶ Dafoe WA. Appendix: table of energy requirements for activities of daily living, household tasks, recreational activities, and vocational activities. In: Pashkow FJ, Dafoe WA, editors. Clinical cardiac rehabilitation: a cardiologist's guide. Baltimore, MD: Williams and Wilkins, 1993; 359-376.

⁴⁵⁷ Jetté M et al. Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. Clin Cardiol. 1990 Aug;13(8):555-65.

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If the metabolic cost of doing CPR is about 4.75 METS, then lifeguards that are able to do the above tasks, should be able to do CPR almost indefinitely BECAUSE (and this is important), the metabolic cost of doing CPR is only 60% of the cost of the above exercise. Importantly, this means that when doing CPR, the metabolic cost is not so intense that they will be doing effort that will increase the amount of lactate in their blood (i.e. they won't go above lactate threshold) and if they stay below lactate threshold (60-65% max intensity) they should be able to do CPR a long time.

The United States national average response time for a BLS ambulance is 10 minutes. Paramedics are 12-15 minutes. For this reason, QUALIFIED LIFEGUARDS should be fit enough to do the rescue and do CPR for at least this for this time frame.

6.3.3.5 AHJ Authority to Approve Safety Plan LG

Some jurisdictions will have the resources to review the SAFETY PLAN and others may not. These line items allow for that flexibility but as a matter of enforcement, the submittal of the SAFETY PLAN is required in either scenario. Should an incident occur in which the jurisdiction is investigating, the SAFETY PLAN on file would be a good point of reference. The Technical Committee agreed that there needs to be an SAFETY PLAN that is retained and available for review by the AHJ as a point of reference detailing the intended operation to compare to the operation observed in the field.

6.3.3.5.1 Safety Plan on File LG

The SAFETY PLAN itself should be a tool for facility staff to utilize and as such should be present at the AQUATIC FACILITY and not merely a book sitting on a shelf in an administrative office.

6.3.3.5.2 Subject for Implemented LG

The code is written to be performance-based and since each AQUATIC FACILITY is different, each SAFETY PLAN may be different. The SAFETY PLAN is developed to be a written document that establishes the processes the AQUATIC FACILITY will employ to be compliant with the code. It is important to also put in the code that those processes, although written, are also practiced and in evidence for the AHJ to see and compare the operation to what is written in the SAFETY PLAN and therefore compliant with the code. During routine inspections, the AHJ may want to see the SAFETY PLAN for the AQUATIC FACILITY as a point of reference but also to enforce a requirement of the code to have a plan.

6.3.4 Staff Management

6.3.4.3 Lifeguard Staff

6.3.4.3.1 Minimum Number of Lifeguards LG

6.3.4.3.2 Lifeguard Responsibilities LG

QUALIFIED LIFEGUARDS are the front line personnel at an AQUATIC FACILITY to witness most of the situations in which an AQUATIC FACILITY or AQUATIC VENUE should be closed. The

QUALIFIED LIFEGUARD must be aware of these emergency closure issues in order to enforce them – examples include an inability to see the bottom or main drains, fecal accidents, severe weather, and others developed by the MAHC.

The Technical Committee agreed that since there is no established guideline for vision needed for the job of a QUALIFIED LIFEGUARD that if the individual QUALIFIED LIFEGUARD has corrected vision via lenses that they should wear them while conducting PATRON surveillance. Further research needs to be done in this area. Some professions require a minimum vision STANDARD non-corrected while others accept corrected vision to a certain level.

6.3.4.3.3 Shallow Water Certified Lifeguards LG

If a training agency issues a shallow water certification, the shallow water lifeguard is not qualified to be stationed in a zone that has water greater than that identified for the certification. If any part of the zone has a depth of water greater than that depth, the shallow water lifeguard is not qualified to be assigned to that zone.

6.3.4.3.4 Direct Surveillance LG

The factors of recognition, intrusion, and distraction have been identified as major contributor to drowning in guarded venues. Nothing should be allowed to interfere with a lifeguard's duty to perform PATRON surveillance. The Technical Committee all agreed that QUALIFIED LIFEGUARDS performing PATRON surveillance should not be doing other tasks that could distract them.

When on duty, a QUALIFIED LIFEGUARD should scan and supervise the AQUATIC VENUE with no other distracting activities such as cleaning, water testing, and minimize unnecessary conversing with PATRONS.

6.3.4.3.5 Distractions LG

When QUALIFIED LIFEGUARDS are engaged in conversations while performing PATRON surveillance activities their attention is distracted from surveillance. As a parallel, research has shown that even hands-free cell phone conversations can cause drivers to be distracted.⁴⁵⁸

6.3.4.4 Supervisor Staff LG

6.3.4.4.1 Lifeguard Supervisor Required LG

The LIFEGUARD SUPERVISOR fulfills the role of making QUALIFIED LIFEGUARDS accountable for performing well and make sure the rotations are conducted properly. It is critical that QUALIFIED LIFEGUARDS perform their duties as trained and that the risk factors that affect the QUALIFIED LIFEGUARD'S ability to perform have been mitigated. In addition, someone should be responsible for maintaining equipment and knowing when an AQUATIC FACILITY should close and should know how to mitigate hazards. This level of skill is different

⁴⁵⁸ Olson RL et al. Driver distraction in commercial operations. U.S. Department of Transportation Technical report FMCSA-RRR-09-042. September 2009. Report is accessible at <http://www.distraction.gov/research/PDF-Files/Driver-Distraction-Commercial-Vehicle-Operations.pdf>

from that of the QUALIFIED LIFEGUARD and each of these skills is important to have on-site anytime the AQUATIC FACILITY is open.

The Technical Committee considered requiring a LIFEGUARD SUPERVISOR for all AQUATIC FACILITIES, but for a single guard facility, there is no requirement as a QUALIFIED LIFEGUARD doubling as a supervisor would be a redundancy. The SAFETY PLAN should address the means of providing oversight and direction to lifeguards at single guard facilities.

6.3.4.4.2 Designated Supervisor **LG**

For any AQUATIC FACILITY, someone must be designated to make decisions and provide oversight of expected performance. When an AQUATIC FACILITY is required to have two or more QUALIFIED LIFEGUARDS, one of the QUALIFIED LIFEGUARDS may be designated as the LIFEGUARD SUPERVISOR as long as they comply with the training requirements. The QUALIFIED LIFEGUARD cannot fulfill LIFEGUARD SUPERVISOR duties while on scanning duty. For small AQUATIC VENUES, the Technical Committee was sensitive to requiring an additional person simply to be the LIFEGUARD SUPERVISOR. In this scenario, one of the QUALIFIED LIFEGUARDS is designated as the LIFEGUARD SUPERVISOR to make decisions when appropriate.

6.3.4.5 Emergency Response and Communications Plans **RM**

6.3.4.5.1 Emergency Response and Communication Plan **RM**

Chemical STORAGE and EAP/evacuation info also must be filed with local fire/hazmat agency according to quantities and chemical types stored.

6.3.4.5.5 Training Documentation **RM**

It is recommended that EAP Drills are conducted with the staff on a quarterly basis as specified by the American Heart Association; however each operation is unique. Some operations may only be open during specific seasons, etc.

6.3.4.5.8 Communication Plan **RM**

6.3.4.5.8.2 Notification Procedures **RM**

Refer to the Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-To-Know Act titled (EPCRA) and Section 112(r) of the Clean Air Act:

- http://emergencymanagement.wi.gov/EPCRA/forms/EPA_List_of_Lists1.pdf

6.3.4.5.9 Inclement Weather Plan **RM**

It is recommended that employees monitor real time weather sources along with other techniques recommended by organizations such as NOAA. Also, include guidance on securing equipment in preparation for inclement weather. Consider having an evacuation plan to relocate PATRONS to a safe location during the storm. Be prepared by MONITORING weather and closing the facility in time to evacuate.

6.3.4.6 Remote Monitoring Systems**RM**

Remote MONITORING systems should be used as an additional tool to improve health and SAFETY but are not to replace or substitute for aquatics staff or their duties.

6.3.4.6.1 Lifeguard-Based**RM**

A remote SAFETY MONITORING system is an added value but should not be a substitute for a having a lifeguard present when conditions deem that a lifeguard is necessary.

The following excerpts from YMCA guidance provide an overview and discussion of lifeguard-based remote SAFETY MONITORING systems:

- “Speed is critical in recognizing and responding to aquatic emergencies. Time lost in the recognition phase of an EMERGENCY ACTION PLAN can prevent lifeguards from quickly reaching a swimmer in trouble and reduces the likelihood of a positive outcome. Appropriate protocols, combined with aquatic SAFETY technology, such as a surveillance system or alarms, may save valuable time during an emergency.
- “The following are types of aquatic SAFETY technology currently available on the market:
 - Video Camera Surveillance Systems – Underwater and surface video MONITORING systems can help analyze activity in the AQUATIC VENUE and be used to assist lifeguards in MONITORING swimmers. Some systems can alert the lifeguard when a swimmer is in trouble.
 - Wireless Alarm or Water Activated Alarms Systems – A water-activated alarm or wireless sensor button is a portable aquatic emergency summoning device. Such a device allows the lifeguard and/or others to be notified almost immediately to a potential aquatic emergency. Lifeguards can immediately respond, rather than having to first travel to the emergency call button and counselors and day care staff can immediately notify lifeguards of an unintentional submersion.
- “These technology systems DO NOT replace the need for continuous lifeguard surveillance, but they can assist a lifeguard in their surveillance duties. Use of these systems requires assessment and evaluation of current emergency protocols to incorporate the system within your EMERGENCY ACTION PLANNING. Integration of technology requires new approaches to lifeguard in-service training programs to emphasize recognition, surveillance, and prevention of over reliance on technology. Additionally, plans to address power outages or other system failures should be developed.”⁴⁵⁹

6.3.4.6.2 Operator-Based**RM**

Operator-based remote water quality MONITORING systems shall not be in absence of manual testing of the AQUATIC VENUE.

⁴⁵⁹ YMCA. Aquatics Safety & Risk Reduction Document, Topic: Aquatic Safety Technology. 2009.

6.3.4.7 Employee Illness and Injury Policy

RM

6.3.4.7.2 Open Wounds

RM

Open wounds may become entry points for pathogens and are the greatest risk to the wounded person. Water-related work could be allowed with physician approval or if the wound is covered with an occlusive, waterproof bandage.

6.4 Facility Management

Facility management is critical in preventing illness and injury as summarized in this section. The Centers for Disease Control and Prevention (CDC) identifies the most frequently reported contributing factors to the spread of recreational water illnesses, in particular gastroenteritis. Another report identified the most frequently reported type of recreational water illness (RWI) outbreak as gastroenteritis, the incidence of which is increasing⁵ Prevention of RWIs at treated venues requires POOL operators to:

- Maintain appropriate disinfectant and pH levels to maximize disinfectant effectiveness and
- Ensure optimal water circulation and filtration.

A study of POOL inspection data underscored the need for improved maintenance.⁴⁶⁰ A total of 13,532 (12.1%) of 111,487 inspections identified serious violations that threatened the public's health and resulted in immediate POOL closure. Of 120,975 inspections, 12,917 (10.7%) identified disinfectant level violations; of 113,597 inspections, 10,148 (8.9%) identified pH level violations. Other water chemistry violations were documented during 12,328 (12.5%) of 98,907 inspections, with the number identified per inspection ranging from zero to four. Circulation and filtration violations were documented during 35,327 (35.9%) of 98,361 inspections, with the number identified per inspection ranging from zero to nine. The following violations also were identified: improperly maintained POOL log (12,656 [10.9%] of 115,874 inspections), unapproved water test kit used (2,995 [3.3%] of 90,088 inspections), valid POOL license not provided and/or posted (741 [2.7%] of 28,007 inspections), and operator training documentation not provided and/or posted (1,542 [18.3%] of 8,439 inspections).

Of the 121,020 inspection records, 59,890 (49.5%) included POOL setting data. Among venues with known POOL settings, child-care POOL inspections had the highest percentage of immediate closures (17.2%), followed by hotel/motel and apartment/condominium POOL inspections (15.3% and 12.4% respectively) (Table 1: <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5919a2.htm#tab1>).

Apartment/condominium and hotel/motel POOL inspections had the highest percentage of disinfectant level violations (13.1% and 12.8%, respectively). Child-care and apartment/condominium POOL inspections had the highest percentage of pH level violations (11.8% and 10.0%, respectively). Approximately 35% of inspections of

⁴⁶⁰ Centers for Disease Control and Prevention. Violations identified from routine swimming pool inspections – selected states and counties, United States, 2008. MMWR Morb Mortal Wkly Rep. 2010;59(19):582-587.

apartment/condominium POOLS, hotel/motel POOLS, and water parks identified circulation and filtration violations.

Of the 121,020 inspection records, 113,632 (93.9%) included POOL type data. Interactive fountain inspections had the highest percentage of immediate closures (17.0%). Kiddie/WADING POOL inspections had the highest percentage of disinfectant level violations (13.5%), followed by interactive fountain inspections (12.6%). THERAPY POOL inspections had the lowest percentage of disinfectant and pH level violations but the highest percentage of other water chemistry violations (43.9%). Interactive fountain inspections identified the lowest percentage of circulation and filtration violations (12.8%).

Drowning and falling, diving, chemical use, and suction injuries continue to be major public health injuries associated with AQUATIC VENUES. Drowning is a leading cause of injury death for young children ages 1 to 4, and the fifth leading cause of unintentional injury death for people of all ages.⁴⁶¹ From 2008 through 2010, an average of 5,100 POOL- or SPA-related emergency department (ED)-treated submersion injuries occurred each year. For 2006-2008, 383 POOL- or SPA-related fatalities involved children younger than 15 years of age. Approximately 45% of the estimated injuries for 2008 through 2010 and 28% of the fatalities for 2006 through 2008 involving children younger than 15 occurred in a public setting.⁴⁶²

For 2007-2008, 32 POOL chemical--associated health events that occurred in a public or residential setting were reported to CDC by Maryland and Michigan. These events resulted in 48 cases of illness or injury; 26 (81.3%) events could be attributed at least partially to chemical handling errors (e.g., mixing incompatible chemicals). ATSDR's Hazardous Substance Emergency Events Surveillance System received 92 reports of hazardous substance events that occurred at AQUATIC FACILITIES. More than half of these events (55 [59.8%]) involved injured persons; the most frequently reported primary contributing factor was human error. Estimates based on CPSC's National Electronic Injury Surveillance System (NEISS) data indicate that 4,574 (95% confidence interval [CI]: 2,703--6,446) emergency department (ED) visits attributable to POOL chemical--associated injuries occurred in 2008; the most frequent diagnosis was poisoning (1,784 ED visits [95% CI: 585--2,984]).⁴⁶³

The information identified in this report along with existing recreational water injury data and first hand inspector experience drove the development of the critical risk factors for recreational water injury and illness at treated AQUATIC VENUES. The eight broad critical risk factors for recreational water illness and injury are:

⁴⁶¹ Centers for Disease Control and Prevention. Wide-ranging OnLine Data for Epidemiologic Research (WONDER) [online]. (2010) Available from URL: <http://wonder.cdc.gov/mortsql.html>.

⁴⁶² Gipson K. Pool or Spa Submersion: Estimated Injuries and Reported Fatalities, 2011 Report. U.S. Consumer Product Safety Commission, May 2011. Available online at <http://www.cpsc.gov/LIBRARY/FOIA/FOIA11/os/pools2011.pdf>.

⁴⁶³ Centers for Disease Control and Prevention. Pool chemical--associated health events in public and residential settings — United States, 1983-2007. *MMWR Morb Mortal Wkly Rep.* 2009;58(18):489-493.

- Management; supervision; training; operation
- Lifeguard services
- Disinfectant residual
- pH level (low or hi)
- Water clarity
- Facility ENCLOSURE; entry protection
- Entrapment protection
- Water supply/waste disposal

Low or absent disinfectant levels lead to reduced inactivation of pathogens and these conditions have been associated with infectious disease outbreaks.⁴⁶⁴ Low pH has been associated with loss of dental enamel.^{465,466,467} Dental erosion begins to occur below pH 6.0 and rapidly accelerates as the pH drops. High pH reduces the efficacy of CHLORINE-based DISINFECTION by reducing the amount of molecular hypochlorous acid (HOCl), the active form that is available for DISINFECTION. At pH 7.0, about 70% of the hypochlorous acid is molecular, at pH 7.5 about 50% is molecular, at pH 8.0 about 20% is molecular, and at pH 8.5 only 10% is molecular. As a result, the MAHC decided to set upper and lower limits for pH as an IMMINENT HEALTH HAZARD.

6.4.1 Operations

6.4.1.1 Operations Manual

FMO

6.4.1.1.1 Develop

FMO

The facility design consultant can provide valuable assistance with preparation of a manual based on their knowledge of the physical system. The facility owner/operator must provide their preferences for operation and maintenance activities, based on location, climate, programs, budget, etc.

6.4.1.1.2 Include

FMO

A manual for the operation of AQUATIC FACILITIES should be kept at the facility, in both printed and digital formats. The manual should include basic information, chemical data, and operation and maintenance instructions about each POOL, SPA and spray ground feature at the facility. The manual should be updated on a regular basis to include added features, renovation work, and new code requirements.

Safety Related Info

FMO

⁴⁶⁴ Centers for Disease Control and Prevention. Pool chemical–associated health events in public and residential settings — United States, 1983-2007. MMWR Morb Mortal Wkly Rep. 2009;58(18):489-493.

⁴⁶⁵ Centerwall BS *et al.* Erosion of dental enamel among competitive swimmers at a gas-chlorinated swimming pool. Am J Epidemiol. 1986;123(4):641-7.

⁴⁶⁶ Dawes C, Boroditsky CL. Rapid and severe tooth erosion from swimming in an improperly chlorinated pool: case report. J Can Dent Assoc. 2008;74(4):359-61.

⁴⁶⁷ Geurtsen W. Rapid general dental erosion by gas-chlorinated swimming pool water. Review of the literature and case report. Am J Dent. 2000;13(6):291-3.

PATRON and staff SAFETY are paramount to responsible operation of an AQUATIC FACILITY. Provide SAFETY related information in the operations manual including, but not limited to the following:

- Diving, drowning and electrocution hazards and risk reduction procedures
- SAFETY signage locations and message information
- Chemicals (type and quantity stored, MSDS information, delivery procedures)
- Chemical SAFETY equipment and procedures
- Emergency procedures for staff
- Emergency procedures for PATRONS
- Inventory of PATRON SAFETY equipment (first aid kit, back board, head restraints, rescue tubes, throw ropes, rescue pole, etc.)
- Fire SAFETY equipment locations, operation and Public Safety Department notification plan (fire extinguishers, hydrants, sprinkler system)
- Staff training and practice drill schedule and procedures
- Electrical system, controls, and GFCI's
- Lighting and ventilation system description and controls
- Vehicle and pedestrian accessibility
- Lightning and storm evacuation plan
- Emergency phone location and access
- Emergency plan for evacuation and area notification
- Maintain an injury log

Aquatic Venue Info

FMO

Key criteria for each AQUATIC VENUE should be summarized including, but not necessarily limited to the following:

- Basin materials (wall and floor structures, gutter system)
- Coating materials
- Flotation protection (underdrain system, sump pump, hydrostatic relief valves, etc.)
- Surface area (square feet of water or wet DECK for interactive water AQUATIC VENUES)
- Volume (gallons)
- TURNOVER period (TURNOVERS per day)
- Recirculation rate (gallons per minute)
- Filter loading rate (gallons per minute per square foot of filter surface area)
- Special features flow rates (gallons per minute for slides, sprays, LAZY RIVERS, current channels, vortex areas, surf features, play features, etc.)

Chemical Data

FMO

The operations manual should also provide chemical data for each chemical system in the facility. This includes but is not necessarily limited to the following:

- Description of chemicals provided for primary disinfectant, pH adjustment, alkalinity adjustment, stabilizer, SUPERCHLORINATION, coagulant, filter aid, etc.
- SECONDARY DISINFECTION SYSTEM description, if provided (UV, ozone, other)
- Type of chemical feed equipment and rated capacities
- Discussion of water treatment goals and range of chemical targets
- Description of chemical testing equipment
- Testing frequency and location for each test
- Chemical controller information, probe cleaning and calibration procedures
- Water testing log forms for chemical results
- Chemical supplies (STORAGE quantity, providers, SAFETY procedures)

Facility Operation Info

FMO

The operations manual should also provide instructions for AQUATIC FACILITY operations. These instructions should include, but not necessarily be limited to the following:

- Filter backwash or cleaning schedule and procedure
- Periodic vacuuming and cleaning schedule and procedures
- Seasonal cleaning procedures SUPERCHLORINATION basis and procedure
- Controller sensor maintenance (if applicable)
- Preventative maintenance tasks and schedule
- Winterizing procedures
- Start-up and closing procedures

Maintenance Instructions

FMO

The operations manual should provide instruction for proper maintenance for the facility. Both daily and seasonal or periodic maintenance will be required for your AQUATIC FACILITY. Available time and budget must always be balanced with the maintenance need. Regardless of whether your facility is large or small, frequent maintenance is more effective and more efficient than waiting until a larger problem occurs.

- Provide an inventory of available maintenance equipment and materials.
- Develop a daily maintenance schedule.
- Develop a schedule for periodic or seasonal maintenance.
- Create a maintenance log with date and activity for future planning and budgeting.

Office Management

FMO

The operations manual also provides office management information for the facility. This manual should include, but not be limited to following:

- Active and inactive records and general file information
- Forms for water test results and filter cleaning frequency
- Forms for inventory of chemicals, equipment, cleaning supplies, etc.
- Maintenance inspection forms for facility, equipment and structures
- Maintenance work forms

- Requisition forms for purchasing based on facility policies
- Staff evaluation forms log
- POOL operation log (water quality, attendance, weather, open hours, injuries, complaints, equipment issues, etc.)
- Security (opening and closing, underwater lighting, overhead lighting, doors, windows, alarms, bank deposits, etc.).

Personnel Records

FMO

Accurate records should be maintained for all personnel.

The options for this category are varied and numerous. The following list of personnel items is offered as an outline and a starting point for developing an operations manual including, but not limited to the following:

- Staff qualifications and job descriptions
- Payroll procedures
- Facility policies
- Schedules and work attendance
- Vacation and sick leave
- Benefits
- Conferences and education Training programs
- Termination basis
- Accident prevention

Budget Considerations

FMO

An accurate and feasible budget is critical for ongoing AQUATIC FACILITY operation. Budget considerations should be included, but not limited to the following:

- Program fees and policies
- Rental rates and policies
- Staff wages and benefits
- Facility expenditures for utilities, chemicals, concession supplies, equipment, training and program supplies, repairs and maintenance, insurance and office administration.
- Financial report including monthly and annual summaries, projections and trends.

6.4.1.2 Preventive Maintenance and System Check Program and Recordkeeping

6.4.1.2.3 Illness and Injury Reports

REG

6.4.1.2.3.1 Record

REG

Aquatic injuries and illnesses can occur after normal office working hours; therefore, a 24/7 system for reporting and responding to injury and illnesses at AQUATIC VENUES must be maintained. Early reporting and intervention could reduce the spread of illness or prevent additional injury.

6.4.1.2.3.3**Notify****REG**

The POOL owner/operator should immediately report to the permit issuing official any injuries resulting in death or that require emergency medical response, resuscitation or transport to medical facility, or any illness suspected of being associated with bathing water quality or use of the AQUATIC FACILITY. The POOL owner/operator will have posted and available for use the routine phone numbers and after hours phone numbers necessary for reporting to the permit issuing official. This will facilitate a rapid investigation of the incident and could result in limiting further spread of disease and additional injuries.

Most jurisdictions have some reporting requirements. This section is more comprehensive than the existing reporting requirements of many jurisdictions. Prompt reporting of significant injuries or waterborne illness allows for the permit issuing agency to immediately assess the conditions at the AQUATIC VENUE to determine if it can continue to operate safely or must be closed. Prompt reporting and investigation also allows for more accurate investigations to determine the causes of injury and illness. This information can be used to prevent future injuries or illness.

- For more information on the Virginia Graeme Baker Pool and Spa Safety Act, please see: <http://POOLSafely.gov/state-local-officials/pool-spa-safety-act-requirements/>.
- Also see the CPSC Staff guidance in interpreting the act at: <http://poolsafely.gov/pool-spa-safety-act/interpretations-guidelines/>.

6.4.1.2.5**Daily Water Monitoring and Testing Records****FMO**

These duties include but are not limited to:

- Measure and record (or supervise and ensure the measurement and recording of) all information as required by MAHC operations, testing, MONITORING, and reporting requirements.
- Maintain the filtration and RECIRCULATION SYSTEM as required to maintain minimum flow rates required by MAHC 4.7.1.
- Backwash the filtration system when the filter gauge pressure differential reaches a level specified by the equipment manufacturer or as specified in the MAHC 4.7.2.
- Maintain disinfectant residuals according 4.7.3;
- Maintain water chemistry according to MAHC 5.7.3;
- Monitor water temperature to ensure it is within range specified in MAHC Section 4.7.3.
- Clean accessible POOL surfaces as necessary to remove slime/biofilm accumulation.
 - Biofilms are structured communities of microorganisms encapsulated within a self-developed polymeric matrix that adhere to a living or inert surface. In AQUATIC VENUES, biofilms form readily in water distribution and recirculation lines, filters, collector tanks, and swimming POOLS. Biofilms form when bacteria begin to excrete a slimy, sticky substance that allows

them to adhere to surfaces. The biofilm mass usually consists of many species of bacteria, and can also include fungi, algae, and protozoa. Biofilms are resistant to CHLORINE and are difficult to remove once initial adhesion occurs. The biofilm slime shelters disease-causing microorganisms, protecting them from CHLORINE DISINFECTION. In addition, biofilms exert an oxidant demand, consuming CHLORINE residuals in the distribution line and requiring higher doses at the treatment station for residual maintenance at the end of the line.

- Add replacement water as needed to meet all MAHC requirements.

Ensure HYGIENE FACILITIES are clean, sanitary, and supplies needs for swimmer hygiene such as toilet paper and soap or hand SANITIZER are available for use as per Section 5.10.10 of the MAHC.

6.4.1.2.8 Body Fluids Remediation Log

FMO

See MAHC Fecal Vomit and Blood Provisions in Section 6.5 for specific STANDARDS. For the CDC protocol for cleaning body fluid spills from POOL DECKS, see the document entitled "Cleaning up Body Fluid Spills on Pool Surfaces" which can be found on the CDC Healthy Swimming/Recreational Water website at <http://www.cdc.gov/healthywater/swimming/pools/cleaning-body-fluid-spills.html>. A sample body fluid contamination response log can be found with the Fecal Vomit and Blood Provisions in Section 6.5

<i>Body Fluid Contamination Response Log</i>						
Person Carrying out Contamination Response						
Supervisor on Duty						
Date of Contamination Response (mm/dd/yyyy)						
Time of Response						
Location Contaminated						
Number of People in Water (if applicable)						
Type/Form of Contamination: Fecal Accident (Formed Stool or Diarrhea), Vomit, Blood						
Time that Contaminated Area was Closed						
Is Stabilizer Used in the Water? (Yes/No) (if applicable)						
If Yes, Stabilizer Concentration at Time of Contamination Response						
	Water Quality Measurements					
Columns 1-4 are measurements spread evenly thru the closure time.	Level at Closure	1	2	3	4	Level Prior to Reopening
Free Residual Chlorine						
pH						
Date that Contaminated Area was Reopened (mm/dd/yyyy)						
Time that Contaminated Area was Reopened						
Total Contact Time Time from when disinfectant reached target level to when disinfectant levels were reduced prior to re-opening						
Remediation Procedure(s) Used and Comments/Notes						

6.4.1.2.8.1 Contamination Incidents

FVB

The Body Fluid Contamination Response Log is an important part of the administrative procedures for the venue and will document, in the case of a subsequent fecal, vomit, or

“This information is distributed solely for the purpose of pre-dissemination public comment under applicable information quality guidelines. It has not been formally disseminated by the Centers for Disease Control and Prevention. It does not represent and should not be construed to represent any agency determination or policy.”

blood contamination incident, that an appropriate response was conducted. A sample Body Fluid Contamination Response Log is provided below:

6.4.2 Patron-Related Management Aspects

6.4.2.1 Bather Load **RM**

6.4.2.2 Signage **RM**

The purpose of this is to limit injuries and the spread of communicable disease spread by direct contact with objects.

Healthy swimming messages can also be put on posters hung in bathroom stalls, at the AQUATIC FACILITY entrance, on the back of ticket stubs, and in group-event contracts.

Ideally, signage should be provided to encourage BATHERS to take a second shower after using the toilet before reentering the AQUATIC VENUE.

While this requirement may be difficult to enforce, the posting of such signs may encourage compliance.

Consider the needs of clients and provide effective communication which could include signs in more than one language, Braille, etc.

6.4.2.2.4 Sign Messages **RM**

Suggested content for waterslides should also include content on their signs to comply with the manufactures recommendations. Minimum content should include:

- Rider position,
- Number of riders allowed at a time,
- DISPATCH instructions,
- Water depth at slide exit, and
- Height requirement if specified by manufacturer.

6.4.2.2.6 Spa Venue Signs **RM**

See discussion on temperature and relevant data pertaining to SPA temperatures in MAHCsection 5.7.4.6.2. These data have been used to support wording for SPA venue signs.

Suggested Spa Sign Content

- Post signs with suggested time limits.(15 minutes)
- It is recommended that all SPAS have the following statement included on the signage. "Depth of spa is variable. Enter with caution."
- Other suggested SPA and SAFETY equipment.
- Place time clocks with numbers large enough to read from a distance on a nearby wall in clear view of all users.

- Place a thermometer on the wall with numbers large enough to read from a distance or place one in the SPA itself.
- Place a 10-minute timer on the water jets. The reset button should be placed at least 10 feet (3m) from the tub so users must physically leave the tub to turn the water jets on again.

Infants and Toddlers

RM

Infants and toddlers are not recommended in a SPA. Small children are still developing internal temperature regulations. Infants in particular have a small body mass compared to body surface area. HOT WATER also could cause hyperthermia, and a SPA seat is not designed for a small child to sit properly to keep their head above water.

For more information on infants, see the CDC Guidance titled “Breastfeeding in Pools & Hot Tubs/Spas”: <http://www.cdc.gov/healthywater/swimming/pools/breastfeeding-in-pools.html>

6.4.2.2.8 Diaper-Changing Station Signage

HYG

Signage requirements were adapted from the diapering procedure laid out in CFOC⁴⁶⁸.

6.4.2.3 User Guidelines

RM

Equipment should be designed to permit sanitary operation of the facility based on reasonable PATRON use.

Consider increasing the frequency of water chemistry testing, the inspection of restrooms and HYGIENE FACILITIES, and the CHLORINE and pH set points to accommodate higher BATHER LOADS.

6.4.2.4 Swimmer Empowerment Methods

6.4.2.4.1 Public Information and Health Messaging

VEN

The Technical Committee felt strongly that public education and health communication with users should be required at any INDOOR AQUATIC FACILITY. This messaging should make clear the responsibility of the user to shower before entering the POOL and that they should not urinate in the POOL. It is known that urine and sweat contribute nitrogen to the POOL resulting in chloramines. By actively limiting the introduction of urine and sweat, the result should be fewer chloramines in the POOL and the air. A summary of health and exposure data can be found in MAHC Appendix 1.

6.4.2.4.2 Post Inspection Score

REG

There are only a relatively small number of municipal organizations that require public or web-based disclosure of inspection reports. However, as inspection activity is tax-

⁴⁶⁸ American Academy Of Pediatrics, American Public Health Association, and National Resource Center for Health and Safety in Child Care and Early Education (2002). CARING FOR OUR CHILDREN: NATIONAL HEALTH AND SAFETY PERFORMANCE STANDARDS; GUIDELINES FOR OUT-OF-HOME CHILD CARE PROGRAMS, 2ND EDITION. Elk Grove Village, IL: American Academy of Pediatrics and Washington, DC: American Public Health Association. Available at <http://nrckids.org>.

payer supported, there is a growing trend toward requiring public disclosure. One recent example is the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000, a Federal Act that requires public disclosure of coastal beach closings. Additionally, DeKalb County, Georgia requires the public posting of inspection results for AQUATIC FACILITIES as well as posting them on the internet, which is similar to the ever expanding requirement for posting inspection results at food service establishments. The posting of inspections at AQUATIC FACILITIES will increase public awareness of aquatic SAFETY and health and encourage aquatic operators to comply with all code requirements.

6.4.2.4.3 Certificates Retained

REG

Most jurisdictions require the permit to be conspicuously posted. This is to inform the public that the facility has met the minimum SAFETY STANDARDS required by law.

6.5 Fecal/Vomit/Blood Contamination Response

The following discussion gives the rationale behind the remediation recommendations. Fecal contamination of recreational water is an increasing problem in the United States and other countries. Since the mid 1980's, the number of outbreaks of diarrheal illness associated with recreational water has been increasing in the United States.⁴⁶⁹ Of these outbreaks, disinfected, man-made swimming venues, the target of the MAHC, have had the greatest increase. These outbreaks are usually a result of people swimming while they have infectious, pathogen-containing diarrhea caused by pathogens such as *Cryptosporidium*, *Giardia*, *Shigella*, *Salmonella*, or *E. coli* O157:H7. Contamination of swimming water by infected persons and subsequent swallowing of contaminated water by other swimmers continues the spread of diarrheal illness.

Diarrheal illness is common in the United States with surveys indicating that 7.2-9.3% of the general public have had diarrhea in the previous month.⁴⁷⁰ Additional studies demonstrated that people routinely have a mean of 0.14 grams (range = 0.1 to 10 grams) of fecal contamination on their buttocks and peri-anal surface.⁴⁷¹ The increase in outbreaks, the high prevalence of diarrheal illness in the public, and likelihood of frequent fecal contamination of POOLS by BATHERS raised the question of how to respond to overt fecal releases, particularly formed stools that were more visible, in POOLS. The need to develop a response plan was amplified by the emergence of the CHLORINE-resistant parasite *Cryptosporidium* as the leading cause of disinfected venue-associated outbreaks of diarrheal illness. First, formed stools were thought to be a significantly lower risk for spreading illness compared to diarrhea, since most pathogens are shed in the greatest numbers in diarrhea. As the highest risk material, diarrhea was thought of as the worst case contamination scenario that could potentially contain

⁴⁶⁹ Hlavsa MC, Roberts VA, Anderson AR, Hill VR, Kahler AM, Orr M, Garrison LE, Hicks LA, Newton A, Hilborn ED, Wade TJ, Beach MJ, Yoder JS. Surveillance for waterborne disease outbreaks and other health events associated with recreational water use — United States, 2007–2008. *MMWR Surveill Summ.* 2011;60:1-37.

⁴⁷⁰ Jones TF, Mcmillian MB, Scallan E, Frenzen, Cronquist AB, Thomas S, Angulo FJ. A population-based estimate of the substantial burden of diarrhoeal disease in the United States; FoodNet, 1996–2003. *Epidemiol Infect* (2007); 135:293–301.

⁴⁷¹ Gerba CP. Assessment of enteric pathogen shedding by bathers during recreational activity and its impact on water quality. *Quant Microbiol* (2000); 2:55-68.

Cryptosporidium. As a result, a response should require the extreme treatment conditions needed to inactivate *Cryptosporidium*. Formed stool was assessed as a lower risk than diarrhea but several questions remained. Should formed stools be treated as potentially infectious materials? If so, then should the stool be treated as a potential *Cryptosporidium* contamination event like diarrhea (i.e., longer inactivation time) or could it be treated to inactivate all other pathogens other than *Cryptosporidium* (i.e., shorter inactivation time).

To collect data relevant to answering the question above, a study to collect fecal releases from POOLS the United States was conducted in 1999. POOL staff volunteers from across the United States collected almost 300 samples from fecal incidents that occurred at water parks and POOLS.⁴⁷² The Centers for Disease Control and Prevention then tested these samples for *Cryptosporidium* and *Giardia*. *Giardia* was chosen as a representative for moderately-CHLORINE resistant pathogens like hepatitis A virus and norovirus. Using conditions to inactivate *Giardia* would inactivate most pathogens other than *Cryptosporidium*. None of the sampled feces tested positive for *Cryptosporidium*, but *Giardia* was found in 4.4% of the samples collected. These results suggested that formed fecal incidents posed only a very small *Cryptosporidium* threat but should be treated as a risk for spreading other pathogens such as *Giardia*. As a result of these data and the discussion above, it was decided to treat formed stools as potential *Giardia* contamination events, and liquid stool as potential *Cryptosporidium* contamination events.

It was thought that norovirus contamination posed the greatest threat from vomit contamination and that the virus would be inactivated by a formed stool response using *Giardia* inactivation times as discussed above. Further assessment also suggested that blood contamination of POOL water posed little health risk due to the sensitivity of bloodborne pathogens (e.g., viruses, bacteria) to environmental exposure, dilution in the water, and chlorination. In addition, POOL water exposures would lack the requisite bloodborne exposure routes needed to spread the pathogens to other people.

6.5.1 Contamination Response Plan

FVB

The Fecal/Vomit/Blood CONTAMINATION RESPONSE PLAN is a vital part of the administrative procedures for the venue. All staff associated with the operation of the POOL should be aware of the response plan and trained in implementation procedures. At least one responder should be available on- site during all hours of operation.

6.5.1.2.1 Minimum

FVB

A staff member trained in fecal/vomit/blood contamination response should be on site during all operational hours. OSHA discusses occupational issues related to potential bloodborne pathogen exposure in the Bloodborne Pathogens STANDARD, 29 CFR

⁴⁷² CDC. Prevalence of Parasites in Fecal Material from Chlorinated Swimming Pools — United States, 1999. MMWR 2001;50(20):410–2.

1910.1030⁴⁷³ with further discussion under General Guidance⁴⁷⁴ and the OSHA Fact Sheet: OSHA's Bloodborne Pathogens STANDARD⁴⁷⁵.

6.5.2 Water Contamination Response

6.5.2.2 No Vacuum Cleaners

FVB

Questions are often received concerning the MAHC recommendation to **NOT VACUUM** fecal material from the POOL. When the material is drawn through the vacuum, the vacuum itself is then contaminated and must be disinfected. At the present time, the MAHC is not aware of any manufacturer that has a decontamination protocol for disinfecting fecal, vomit or blood-contaminated POOL vacuum units.

6.5.2.3 Treated

FVB

Many conventional test kits cannot measure FREE AVAILABLE CHLORINE levels up to 20 mg/l. Operators should use, in order of preference, a FAS- DPD titration test kit with or without dilutions using CHLORINE-free water, or use test strips that measure FREE AVAILABLE CHLORINE in a range that includes 20 mg/L. The inactivation time should only be started once testing indicates that the intended free CHLORINE level (20 ppm or other free CHLORINE concentration based on inactivation time in table above) has been reached in the POOL.

FAS-DPD should be used instead of a color comparator DPD test.

It is important that the operator use a non-stabilized CHLORINE product when raising the FREE CHLORINE RESIDUAL particularly when raising to high levels such as 40 mg/L. If a stabilized product such as dichlor or trichlor were used, a high level of cyanuric acid would remain in the POOL after the HYPERCHLORINATION process. The cyanuric acid level in POOL water can only be lowered by dilution of POOL water with make-up water. Since CHLORINE products degrade over time, it is not recommended that non-stabilized CHLORINE products be stored in case of a fecal incident. The operator could either purchase a non-stabilized product at a POOL supply store or buy unscented household bleach (sodium hypochlorite) product that has a label indicating it is EPA-approved for use as a drinking water disinfectant.

6.5.3 Pool Water Contamination Disinfection

6.5.3.1 Formed-Stool Contamination

FVB

For **formed-stool contamination**, a free CHLORINE value of 2 mg/L was selected to keep the POOL closure time to approximately 30 minutes. Other CHLORINE concentrations or closure times can be used as long as the CT inactivation value is kept constant. The

⁴⁷³ OSHA. Bloodborne pathogens and needlestick prevention standards. Available at: <http://www.osha.gov/SLTC/bloodbornepathogens/standards.html>. Accessed: 5/1/2013.

⁴⁷⁴ OSHA. Bloodborne pathogens and needlestick prevention. Available at: <http://www.osha.gov/SLTC/bloodbornepathogens>. Accessed: 5/1/2013.

⁴⁷⁵ OSHA. Fact Sheet: OSHA's bloodborne pathogen standards. Available at: http://www.osha.gov/OshDoc/data_BloodborneFacts/bbfact01.pdf. Accessed: 5/1/2013.

CT VALUE is the concentration (C) of FREE AVAILABLE CHLORINE in mg/L multiplied by time (T) in minutes (CT VALUE = C x T).

For formed-stool contaminated water the CT VALUE for *Giardia* (45) is used as a basis for calculations:

Giardia Inactivation Time for Formed-stool Contamination	
Chlorine Levels (mg/L)	Disinfection Time*
1.0	45 minutes
2.0	25 minutes
3.0	19 minutes

**These closure times are based on a 99.9% inactivation of Giardia cysts by chlorine, pH 7.5, 77°F (25°C). The closure times were derived from the Environmental Protection Agency (EPA) Disinfection Profiling and Benchmarking Guidance Manual. They do not take into account "dead spots" and other areas of poor pool water mixing.*

6.5.3.1.1 Pools Containing Chlorine Stabilizers

CHLORINE stabilizers such as cyanuric acid slow DISINFECTION; therefore, higher CHLORINE levels likely are necessary to reach the CT VALUE for *Giardia* inactivation in POOLS using CHLORINE stabilizers. However, at this time there is no standardized protocol to compensate for CHLORINE stabilizers and no data determining how the inactivation of *Giardia* is affected by CHLORINE stabilizers under POOL conditions. A SAFETY value of 2 has been incorporated until these data can be gathered.

6.5.3.2 Diarrheal-Stool Contamination

FVB

For **diarrheal-stool contamination**, inactivation times are based on *Cryptosporidium* (Crypto) inactivation times. The CT VALUE for Crypto is 15,300. If a different CHLORINE concentration or inactivation time is used, an operator must ensure that the CT VALUES remain the same. For example, to determine the length of time needed to disinfect a POOL at 20 mg/L after a diarrheal accident use the following formula: $C \times T = 15,300$. Solve for time: $T = 15,300 \div 20 \text{ mg/L} = 12.75 \text{ hours}$. It would take 12.75 hours to inactivate Crypto at 20 mg/L. See table below:

Cryptosporidium Inactivation Time for Diarrheal Contamination	
Chlorine Levels (mg/l)	Disinfection Time
1.0	15,300 minutes (255 hours)
10.0	1,530 minutes (25.5 hours)
20.0	765 minutes (12.75 hours)

6.5.3.2.1 Pools Containing Chlorine Stabilizers**FVB**

CHLORINE stabilizers such as cyanuric acid slow DISINFECTION; therefore, higher CHLORINE levels may be necessary to reach the CT VALUE for *Cryptosporidium* inactivation in POOLS using CHLORINE stabilizers. Limited data suggest that a 3-log inactivation of *Cryptosporidium* is possible in more extreme conditions when 50 ppm cyanuric acid was present in the water (pH of 6.5, FREE CHLORINE RESIDUAL of 40 mg/L).⁴⁷⁶ The level of cyanurate mentioned above (i.e., 50 ppm) was the concentration used in the experiment and should not be construed with suggested operating conditions; POOL operators should not add additional cyanurate to a POOL to reach 50 ppm. Higher levels of stabilization (i.e., >50 ppm) may or may not decrease DISINFECTION efficacy further so more data are needed to address the issue.

Along with the pH level and FREE CHLORINE RESIDUAL, the cyanuric acid level should be checked and adjusted if necessary prior to reopening the POOL.

Data are not currently available for remediation procedures with POOLS that contain stabilized CHLORINE or cyanuric acid. CDC has extrapolated current data and has the following suggestions for remediation.

In POOL water that contains CHLORINE stabilizer such as cyanuric acid under 50 mg/L, the pH should either be lowered to 6.5 and the FREE CHLORINE RESIDUAL shall be raised to 40 mg/L using a non-stabilized CHLORINE product and maintained for at least 30 hours or an equivalent time to reach the same CT VALUE as shown in the Annex 6.5.3.2. Further data are being collected by CDC to better address the issue of HYPERCHLORINATION of *Cryptosporidium* in POOLS using stabilizers in POOL water that contains CHLORINE stabilizer such as cyanuric acid under 50 mg/L.

Another method for remediation could be reached by dilution, draining the POOL enough water to reach 50 mg/L stabilizer and then following the procedure above. If that cannot be accomplished, the POOL could be drained completely and scrubbed.

AQUATIC VENUES with SECONDARY DISINFECTION SYSTEMS could be closed and allowed to circulate for the length of time calculated in MAHC 4.7.3.3.2.4 to reduce the level of *Cryptosporidium* below 1 OOCYST/100ml

6.5.3.3 Vomit-Contamination**FVB**

For **vomit contaminated** water, the CT VALUE for norovirus is thought to be in the same range as *Giardia* so the same CT VALUES are used as for a formed stool contamination.⁴⁷⁷

⁴⁷⁶ Shields JM et al. The effect of cyanuric acid on the chlorine inactivation of *Cryptosporidium parvum*. J Water Health 2008;6 (4):513-20.

⁴⁷⁷ Shin GA, Sobsey MD. Inactivation of norovirus by chlorine disinfection of water. Water Res. 2008 Nov;42(17):4562-8.

Giardia Inactivation Time for Vomit Contamination	
Chlorine Levels (mg/L)	Disinfection Time*
1.0	45 minutes
2.0	25 minutes
3.0	19 minutes

**These closure times are based on a 99.9% inactivation of Giardia cysts by chlorine, pH 7.5, 77°F (25°C). The closure times were derived from the Environmental Protection Agency (EPA) Disinfection Profiling and Benchmarking Guidance Manual. They do not take into account "dead spots" and other areas of poor pool water mixing.*

6.5.3.4 Blood-Contamination

FVB

If the CHLORINE or bromine residual and pH are in a satisfactory range, there is no public health reason to recommend closing a POOL due to blood contamination. Data suggest that the risk posed by potential bloodborne pathogens is greatly diminished by dilution and normal FREE CHLORINE RESIDUAL levels. However, the operator may wish to temporarily close the POOL for aesthetic reasons or to satisfy PATRON concerns.

6.5.3.5 Procedures for Brominated Pools

FVB

There are no inactivation data for *Giardia* or *Cryptosporidium* for bromine or any developed protocols for how to hyperbrominate a swimming POOL and inactivate pathogens that may be present in fecal matter or vomit. Therefore, POOL operators should use CHLORINE in their DISINFECTION procedures. It should also be noted that DPD test kits cannot differentiate between CHLORINE and bromine. This is because DPD undergoes the same chemical reaction with both CHLORINE and bromine. Therefore, it is important that the POOL's bromine residual be measured before CHLORINE is added to the POOL. This bromine residual should be taken into consideration when determining that the FREE CHLORINE RESIDUAL necessary for the type of contamination has been met (i.e., the FREE CHLORINE RESIDUAL measured minus the bromine residual should be equal to or greater than the intended FREE CHLORINE RESIDUAL). If a DPD test kit with a CHLORINE comparator is used; the total bromine residual can be determined by multiplying the FREE CHLORINE RESIDUAL by a factor of 2.2.

6.5.4 Surface Contamination Cleaning and Disinfection

6.5.4.1 Limit Access

FVB

Body fluids, including blood, feces, and vomit are all considered potentially contaminated with pathogens. Therefore, spills of these fluids on the POOL DECK should be cleaned up immediately. Visible contamination should be removed first, followed by DISINFECTION of the contaminated surfaces.

6.5.4.2 Clean Surface**FVB**

The CDC protocol for cleaning body fluid spills from POOL DECKS entitled “Cleaning up Body Fluid Spills on Pool Surfaces” can be found on the CDC Healthy Swimming/Recreational Water website at <http://www.cdc.gov/healthywater/swimming/pools/cleaning-body-fluid-spills.html> .

These procedures are based on hospital infection control guidelines.⁴⁷⁸

6.5.4.3 Disposal**FVB**

Currently, there are no standardized procedures for removing CONTAMINANTS, particularly those found in biofilms/slime layers, in piping, or AQUATIC FEATURES that spray or dump water. All water features should be well drained and disinfected per manufacturer’s instructions. Development of appropriate guidelines deserves further investigation and data gathering.

6.5.4.4 Disinfect Surface**FVB**

The efficacy of disinfectants is greatly impacted by the organic load on the surface to be disinfected. Reducing the organic load as much as possible through cleaning and removal of all visible contamination BEFORE adding disinfectant is critical to successful DISINFECTION. Contact times apply only if all visible organic material has been removed before DISINFECTION.

6.6 AHJ Inspections**6.6.1 Inspection Process****6.6.1.1 Inspection Authority****REG**

The Health Department has the authority to enter the facility for both routine inspections and to investigate reports of illness and injury. At the time of investigation, all records and facility personnel required for interviews must be available.

6.6.2 Publication of Inspection Forms**6.6.3 Forms****REG**

This section in the CODE is applicable to jurisdictions with oversight by a higher authority.

6.6.4 Imminent Health Hazard Violations**6.6.4.1 Violations****REG**

IMMINENT HEALTH HAZARD violations must be corrected at the time of inspection or the POOL must be closed until the violations are corrected. Whenever a POOL is closed due to a public health violation, signage must be posted stating that the facility is closed due

⁴⁷⁸ CDC. Guidelines for environmental infection control in health-care facilities: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). MMWR (2003);52 (No.RR-10.)

to an IMMEDIATE HEALTH HAZARD. Before removing the closure sign and reopening the feature, A follow-up inspection or other evidence of correction of the violations is required to ascertain correction and re-open the POOL. IMMEDIATE HEALTH HAZARD

The factors being considered IMMEDIATE HEALTH HAZARDS cover known risk areas:

- Low or absent disinfectant levels lead to reduced inactivation of pathogens and these conditions have been associated with infectious disease outbreaks.
- Low pH has been associated with loss of dental enamel. Dental erosion begins to occur below pH 6.0 and rapidly accelerates as the pH drops.^{479,480,481} High pH reduces the efficacy of CHLORINE-based DISINFECTION by reducing the amount of molecular hypochlorous acid (HOCL), the active form that is available for DISINFECTION. At pH 7.0, about 70% of the hypochlorous acid is molecular, at pH 7.5 about 50% is molecular, at pH 8.0 about 20% is molecular, and at pH 8.5 only 10% is molecular. As a result, the MAHC decided to set upper and lower limits for pH as an IMMEDIATE HEALTH HAZARD.
- Injuries/deaths occur to persons using equipment such as vacuums and reach poles at swimming POOLS when this equipment contacts overhead wires which are too close to the POOL.
- Clearance in any direction from the water, edge of POOL, etc. is to protect people using rescue and service equipment at POOLS, which are typically aluminum.
- Clearance in any direction to the diving platform, tower, waterslide or other fixed POOL related structure is to protect a swimmer using these items.
- Follow-up procedure for observance of electrical lines within 20 feet of a swimming POOL during an inspection:
- Determine whether the electrical lines are owned by the utility company or by the owner/operator of the swimming POOL/property.
- If they are owned by the utility company, the operator should obtain a letter from the utility company stating that these lines are in compliance with NEC 680 STANDARDS.
- If the lines are owned by the owner/operator, and there is no waiver or variance, it is a PHH.
- This requirement does not apply to wiring inside walls/ceilings, etc. at an indoor POOL.

⁴⁷⁹ Centerwall BS et al. Erosion of dental enamel among competitive swimmers at a gas-chlorinated swimming pool. Am J Epidemiol. 1986;123(4):641-7.

⁴⁸⁰ Dawes C, Boroditsky CL. Rapid and severe tooth erosion from swimming in an improperly chlorinated pool: case report. J Can Dent Assoc. 2008;74(4):359-61.

⁴⁸¹ Geurtsen W. Rapid general dental erosion by gas-chlorinated swimming pool water. Review of the literature and case report. Am J Dent. 2000;13(6):291-3.

- 6.6.5 Enforcement**
- 6.6.6 Enforcement Penalties**
- 6.6.7 Public Nuisance**
- 6.6.8 Fees**

DRAFT

MAHC Resources

A Note about Resources:

The resources used in all MAHC modules come from peer-reviewed journals and government publications. No company-endorsed publications have been permitted to be used as a basis for writing code or annex materials.

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- ANSI/NSPI-1
- ANSI Z358.1-2004 (Standard for Emergency Eyewashes and Shower Equipment).
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 - Section 1-6.
 - Section 12-3
 - Section 4-4
- American National Standards Institute/National Spa and Pool Institute
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers Handbook—Fundamentals
 - Section 4.6 “Natatoriums – Ventilation Requirements”
- American Society of Mechanical Engineers
- American Society for Testing and Materials
- California Assembly Bill
- Canadian Pest Management Regulatory Agency
- Consumer Product Safety Commission
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- Environmental Protection Agency Osver 90 008.1 Chemical Emergency Preparedness and Prevention Advisory SWIMMING POOL CHEMICALS: Chlorine
- European Standard EN 13451-11:2004
- Federation Internationale de Natation
- International Mechanical Code
 - Section 304.1
 - Section 502
 - Section 701
- International Swimming Pool and Spa Code
- Material Safety Data Sheets
- Sodium Hypochlorite Health Hazard Data

- Calcium Hypochlorite Health Hazard Data
- Hydrochloric Acid Health Hazard Data
- Muriatic Acid MSDS, Health Hazard Data
- National Fire Code
- National Collegiate Athletic Association
- National Electrical Code
 - Article 100 “Location, Wet”
 - Article 110-26 “Minimum clearances”
 - Article 110.11 “Deteriorating Agents”
 - Article 300.7 “Raceways Exposed to Different Temperatures”
- National Electrical Manufacturing Association Standard 250
- National Fire Protection Association
- National Fuel Gas Code Sec. 8.1.2
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- ADA – Americans with Disabilities Act
- AMCA – Air Movement and Control Association
 - 30 West University Drive, Arlington Heights, IL 60004
- www.amca.org
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Lifeguard Resources

Codes Referenced

- 21 CFR Parts 201 and 310
- 29 CFR 1910.1030
- ADA Accessibility Guidelines
- ANSI/APSP-1
- ANSI/APSP-9
- ANSI /ISEA Z308.1-2009
- ICC A117.1-2009
- International Life Saving Federation Pool Lifeguard Requirements

- State Codes: Oregon, Wisconsin, Florida, Texas, Washington, Colorado, Rhode Island, Wyoming, New Hampshire, Louisiana, Massachusetts, Nevada and New York.
- OSHA

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Additional Resources

EMS World Response Time Standards:

<http://www.emsworld.com/article/10324786/ems-response-time-standards>

Prevention of Drowning: Visual scanning the attention span in lifeguards:

<http://www.lifelink.ca/resources/ScanningArticle.pdf>

Effective Lifeguard Rotation video – The Redwoods Group:

<http://www.youtube.com/watch?v=Gm0iGL1hWoM>

Center for Disease Control and Prevention Fecal Incident Response

Recommendations: <http://www.cdc.gov/healthywater/pdf/swimming/pools/fecal-incident-response-recommendations.pdf>

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Additional Resources

“This information is distributed solely for the purpose of pre-dissemination public comment under applicable information quality guidelines. It has not been formally disseminated by the Centers for Disease Control and Prevention. It does not represent and should not be construed to represent any agency determination or policy.”

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Codes Referenced

- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 62, Ventilation for Acceptable Indoor Air Quality
- International Building Code. "Open Building" definition
- International Code Council (ICC) International Mechanical Code, Chapter 4, and/or applicable local codes.
- Oklahoma pool code

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Appendices

Appendix 1: Summary of Health and Exposure Data for Chemical and Biological Contaminants

Appendix 2: Air Quality Formula

Appendix 3: Dye Testing Procedure

Appendix 1: Summary of Health and Exposure Data for Chemical and Biological Contaminants

TRICHLORAMINE threshold research reference synopses:

- TRICHLORAMINE has a pungent CHLORINE odor, is a strong irritant, and causes excessive tearing of the eyes⁴⁸²
- Methods for sampling include⁴⁸³ INRS method [INRS 2007], NIOSH draft methods [method not published] using ion chromatography (IC) and Inductively coupled plasma atomic emission spectroscopy (ICP-AES).
- Based on concentration-response data in mice, the author recommends threshold limit values (TLV) for a short-term exposure limit (TLV-STEL⁴⁸⁴) of 1.5 mg/m³ and an allowable time weighted average (TLV-TWA⁴⁸⁵) of 0.5 mg/m³ for TRICHLORAMINE.⁴⁸⁶
- Health complaints from teenage swimmers and soccer players showed a significant increase in respiratory complaints at chloramine concentrations of 0.37 mg/m³ or greater.⁴⁸⁷
- Symptoms, in a separate study, were not observed until the chloramine concentrations reached 0.5 mg/m³, and everyone reported symptoms when the levels reached 0.7 mg/m³.⁴⁸⁸
- In a study of 334 lifeguards and 63 indoor POOLS, the prevalence of mucous membrane irritation among lifeguards exposed to TRICHLORAMINE levels above 0.5 mg/m³ was 86% for eye irritation, 61% nose irritation, 29% throat irritation, and 42% dry cough.⁴⁸⁹

⁴⁸² Barbee SJ, et al. Acute inhalation toxicology of nitrogen trichloride. Am Ind Hyg Assoc J. 1983;44(2):145-6.

⁴⁸³ Hery M, et al. Exposure to chloramines in the atmosphere of indoor swimming pools. Ann Occup Hyg 1995;39(4):427-439.

⁴⁸⁴ the short-term exposure limit or maximum concentration for a continuous exposure period of 15 minutes (with a maximum of four such periods per day, with at least 60 minutes between exposure periods, and provided that the daily TLV-TWA is not exceeded.)

⁴⁸⁵ the allowable time-weighted average concentration for a normal 8-hour workday or 40-hour week to which a person can be repeatedly exposed for 8 hours a day, day after day, without adverse effect

⁴⁸⁶ Gagnaire F, Azim S, Bonnet P, Hecht G, Hery M. Comparison of the sensory irritation response in mice to chlorine and nitrogen trichloride. J Appl Toxicol. 1994;14(6):405-9.

⁴⁸⁷ Lévesque B, Duchesne JF, Gingras S, Lavoie R, Prud'Homme D, Bernard E, Boulet LP, Ernst P. The determinants of prevalence of health complaints among young competitive swimmers. Int Arch Occup Environ Health. 2006;80(1):32-9.

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⁴⁸⁹ Massin N, Bohadana AB, Wild P, Héry M, Toamain JP, Hubert G. Respiratory symptoms and bronchial

- Airborne TRICHLORAMINE was measured at six indoor swimming facilities and researchers found an elevated prevalence of respiratory symptoms in swimming POOL workers. Mean TRICHLORAMINE concentration of 0.56 mg/m³, with the highest concentration reaching 1.34 mg/m³. General respiratory symptoms were significantly higher in POOL employees compared to the Dutch population sample (odds ratios ranged from 1.4 to 7.2).⁴⁹⁰
- Researchers generated TRICHLORAMINES at 0.5 mg/m³ in a challenge chamber and exposed the participants to a series of 10-minute exposures followed by spirometry. Results showed a decrease in pulmonary function.⁴⁹¹
- TRICHLORAMINE is the most volatile and prevalent chloramine compound in the air around swimming POOLS⁴⁹², has low solubility, and decomposes rapidly in sunlight.
- The World Health Organization proposes a 0.5 mg/m³ provisional value although it states that more research is needed to investigate health effects in people who use the POOL for extended periods of time and the role of TRICHLORAMINE in possibly causing or exacerbating asthma⁴⁹³.
- Although proposed STANDARDS and past studies indicate that a comfort level for indoor POOL areas would be to keep TRICHLORAMINE concentrations below 0.5 mg/m³, there have been some concerns that this level may not be low enough to prevent symptoms.⁴⁹⁴

TRICHALOMETHANE (THM) threshold research reference synopses:

- Animal toxicity studies demonstrate and characterize hepatotoxicity and nephrotoxicity⁴⁹⁵
- Investigation of THMs in tap water and swimming POOL water. The concentrations of total THMs in swimming POOL water was higher than those in tap water, particularly, brominated-THMs. This poses a possible cancer risk related to exposure.⁴⁹⁶
- Environmental and biological MONITORING of THMs was performed in order to assess the uptake of these substances after a defined period in five competitive swimmers. Analyses were performed by gas chromatography. In relation to

responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools. *Occup Environ Med.* 1998;55(4):258-63.

⁴⁹⁰ Jacobs JH, Spaan S, van Rooy GB, Meliefste C, Zaat VA, Rooyackers JM, Heederik D. Exposure to trichloramine and respiratory symptoms in indoor swimming pool workers. *Eur Respir J.* 2007;29(4):690-8.

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⁴⁹⁶ Panyakapo M, et al. Cancer risk assessment from exposure to trihalomethanes in tap water and swimming pool water. *J Environ Sci (China).* 2008;20(3):372-8.

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biological MONITORING, CHCl_3 , CHBrCl_2 and CHBr_2Cl were detected in all alveolar air samples collected inside the swimming POOL⁴⁹⁷

- Methods for testing halogenated hydrocarbons: NIOSH method 1003 halogenated hydrocarbons <http://www.cdc.gov/niosh/docs/2003-154/pdfs/1003.pdf>; experimental method for sampling THMs - Membrane introduction mass spectrometry⁴⁹⁸. *STANDARD Method 6232 C TRIHALOMETHANES and Chlorinated Organic Solvents (PURGE & Trap/Gas Chromatographic/Mass Spectrometric Method) in water found at* <http://www.STANDARDmethods.org/store/ProductView.cfm?ProductID=161>.

Biological contamination research reference synopses:

- *Mycobacterium avium* complex “MAC” is reduced with higher halogen presence and higher TURNOVER rate in hot tubs.⁴⁹⁹
- Mycobacteria are prevalent in POOL water and in air. They tend to aerosolize more than other POOL water CONTAMINANTS.⁵⁰⁰
- *Legionella* presence increased in HOT WATER, in water with pH greater than 7.8 and CHLORINE less than 0.2 ppm.⁵⁰¹
- *Legionella* was more prevalent in showers than POOLS⁵⁰². Low temperatures in showers showed higher *Legionella* prevalence. Over 109°F (43° C) resulted in no *Legionella*.
- For Gram negative bacteria - endotoxin levels of 14,400 in hot tub were considered a contributing factor to acute illness of BATHERS in WI.⁵⁰³;
- 45 - 400 EU (endotoxin units)/m³ was associated with acute airflow obstruction, mucous membrane irritation, chest tightness, cough, shortness of breath, fever, and wheezing.^{504, 505, 506, 507}
- Chronic health effects associated with airborne endotoxin exposures include chronic bronchitis, bronchial hyper-reactivity, chronic airways obstruction, hypersensitivity pneumonitis, and emphysema.⁵⁰⁸

⁴⁹⁷ Aggazzotti G, et al. Blood and breath analyses as biological indicators of exposure to trihalomethanes in indoor swimming pools. *Sci Total Environ*. 1998;217(1-2):155-63.

⁴⁹⁸ Li J, Blatchley ER 3rd. Volatile DISINFECTION byproduct formation resulting from chlorination of organic-nitrogen precursors in swimming pools. *Environ Sci Technol*. 2007;41(19):6732-9.

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⁵⁰⁰ Angenent LT, et al. Molecular identification of potential pathogens in water and air of a hospital therapy pool. *PNAS* 2005;102(13):4860-5.

⁵⁰¹ Goutziana G, et al. *Legionella* species colonization of water distribution systems, pools and air conditioning systems in cruise ships and ferries. *BMC Public Health*. 2008;8:390.

⁵⁰² Leoni E, et al. Prevalence of *Legionella* spp. in swimming pool environment. *Water Res*. 2001;35(15):3749-53.

⁵⁰³ Fields BS, et al. Pontiac fever due to *Legionella micdadei* from a whirlpool spa: possible role of bacterial endotoxin. *J Infect Dis* 2001;184(10):1289-92.

⁵⁰⁴ Castellan RM, et al. Inhaled endotoxin and decreased spirometric values. An exposure-response relation for cotton dust. *N Engl J Med*. 1987;317(10):605-10.

⁵⁰⁵ Smid T, et al. Dust- and endotoxin-related acute lung function changes and work-related symptoms in workers in the animal feed industry. *Am J Ind Med*. 1994;25(6):877-88.

⁵⁰⁶ Milton DK, et al. Worker exposure to endotoxin, phenolic compounds, and formaldehyde in a fiberglass insulation manufacturing plant. *Am Ind Hyg Assoc J*. 1996;57(10):889-96.

⁵⁰⁷ Milton DK, et al. Endotoxin exposure-response in a fiberglass manufacturing facility. *Am J Ind Med*. 1996;29(1):3-13.

- “Lifeguard lung” has been associated with indoor swimming POOL use⁵⁰⁹
- A permanent decrease in pulmonary function, along with respiratory symptoms, has been reported in epidemiological studies.⁵¹⁰
- The *Limulus* ameobocyte lysate (LAL) assay used to analyze for endotoxin LAL assay, is a comparative bioassay.⁵¹¹ However, changes in the LAL test procedures themselves can erroneously appear as changes in the measured endotoxin activity levels. Until problems with the LAL test are resolved, endotoxin results cannot be compared to samples collected at different times or analyzed by different laboratories. For these reasons, the American Conference of Governmental Industrial Hygienists (ACGIH) has proposed that RLVs (Relative Limit Value⁵¹²), rather than the more usual TLVs, be used as a reference for endotoxin.⁵¹³

⁵⁰⁸ Castellan RM. Respiratory health effects of inhaled endotoxins: byssinosis and beyond. In: McDuffie H, Dosman J, Semchuk K, Olenchock S, eds. Agricultural Health and Safety - Workplace, Environment, Sustainability. Boca Raton, FL: CRC Press, 1995; 97–100.

⁵⁰⁹ Rose CS, et al. "Lifeguard lung": endemic granulomatous pneumonitis in an indoor swimming pool. Am J Public Health. 1998;88(12):1795-800.

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⁵¹¹ Milton DK. Endotoxin and other bacterial cell-wall components. In: Macher J, ed. Bioaerosols: assessment and control. Cincinnati, OH: American Conference of Governmental Industrial Hygienists. 1999; 23–1 to 23–14.

⁵¹² Relative Limit Values require that samples be collected from an area considered to represent background levels of endotoxin and be analyzed at the same time as the samples from areas of interest. The RLV is a comparison between the environment in question and background levels. ACGIH states that if health effects are consistent with endotoxin exposure, and if the endotoxin exposures exceed 10 times the simultaneously determined background levels, then the RLV action level has been exceeded, and action should be taken to reduce exposure. The proposed maximum RLV rises to 30 times the background level in an environment where no symptoms are reported. When exposures exceed the RLV action level or maximum RLV, remedial actions to control endotoxin levels are recommended. It is important to note that the nature of the relationship between the RLV and health effects has not been elucidated at this time.

⁵¹³ Milton DK. Endotoxin and other bacterial cell-wall components. In: Macher J, ed. Bioaerosols: assessment and control. Cincinnati, OH: American Conference of Governmental Industrial Hygienists. 1999; 23–1 to 23–14.

Appendix 2: Air Quality Formula

NOTE: Significant numbers of public comments were received regarding the proposed increase, above ASHRAE 62 STANDARDS of required outdoor air. The commenters noted that the requirements will result in increased costs for equipment and operation while lacking adequate data to support the increase. Based on the potential negative impact and the need for additional research and data to differentiate the causes and sources of indoor air quality problems on design criteria (e.g., design, inappropriate operation, inadequate maintenance), the Steering Committee decided to defer to ASHRAE outdoor air requirements in this version of the MAHC. The Steering Committee thought it important to preserve the work done by the Technical Committee, so the proposed code language for additional outdoor air has been moved to Appendix 1 in the MAHC along with preserving the corresponding annex discussion. A research agenda should be developed and should be a priority to better address the contributing factors to indoor air quality problems and the appropriate design and operational requirements needed to address those factors

INDOOR AQUATIC FACILITY AIR HANDLING SYSTEM should have a design capability to supply the minimum outdoor air requirements using Appendix 2 Table below in addition to ASHRAE 62.1:

$$R_{MAHC} = R_a + \frac{R_p}{\text{Density}}$$

Density (ft² / person)

Appendix 2 Table : Factors for Calculating Outdoor Air Requirements for Indoor Aquatic Facilities

Factors	Flat Water	Agitated Water	Hot Water	Deck	Stadium Seating	Modifier
ASHRAE R _a	0.48	0.48	0.48	0.48	0.06	None
Additional CFM per person (R _p)	10	25	60	10	7.5	None
Average density in the pool (sq ft/person)	20	15	10	50	6.6	Based on designer /engineer rationale
cfm/person/ft ²	0.5	1.67	6	0.2	1.14	
R _{MAHC} (Total cfm per sq ft)	0.98	2.15	6.48	0.68	1.2	

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R_a = ASHRAE 62.1 Equivalent (cubic feet per minute / square foot)

R_p = Occupant driven cfm/person

R_{MAHC} is the number of cubic feet per minute (cfm) of outdoor air required for the area.

For Example:

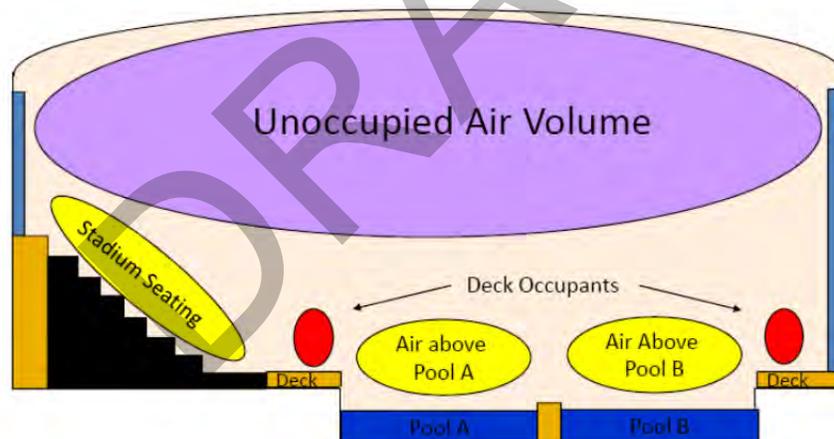
$$R_{MAHC} = R_a + \frac{R_p}{\text{Density}}$$

Density (ft^2 / person)

$$R_{MAHC} (\text{FLAT WATER}) = .48 + \frac{(10 \text{ cfm/person})}{20 \text{ ft}^2/\text{person}} = .98 \text{ cfm/ft}^2$$

20 ft^2 /person

The additional cfm per person addresses the CONTAMINANTS contributed to the air from the individuals in the POOL. This number varies based on the release of CONTAMINANTS to the air, which is dependent upon the agitation of the POOL surface and the occupant density of the various locations within the INDOOR AQUATIC FACILITY as described below and the in Appendix Figure 1.



Appendix Figure 1: Side view of a typical natatorium

- FLAT WATER – area of an AQUATIC VENUE in which the water line is static except for movement made by users. Diving spargers do not void the FLAT WATER definition
- AGITATED WATER – area of an AQUATIC VENUE with mechanical means (AQUATIC FEATURES) to discharge, spray, or move the water's surface above and/or below the static water line of the AQUATIC VENUE. Where there is no static water line, movement shall be considered above the DECK plane
- HOT WATER – area of an AQUATIC VENUE with a water temperature over 90 degrees Fahrenheit
- DECK – area of floor spaces at or near the same elevation as POOL surfaces often used for observation and access.

- Stadium Seating – area of high-occupancy seating provided above POOL level for observation. Generally bleacher style at a higher elevation than the POOL surfaces.

The Density factor in Appendix 2 Table could be modified if the designer/engineer of the INDOOR AQUATIC FACILITY can document the intended use is different (i.e., a swimming POOL is a FLAT WATER venue and is normally 20 ft² per person, but when designing a FLAT WATER WADING POOL, which has a higher density of BATHERS, the number could be modified to 15 ft² per person).

For INDOOR AQUATIC FACILITIES with more than one type of water or seating, the total outside air required is calculated by adding together the air required for each type.

The number of cubic feet per minute (cfm) of outdoor air for an INDOOR AQUATIC FACILITY shall be calculated with the following equation:

$$\begin{aligned}
 & \text{Area of FLAT WATER in ft}^2 \times \text{FLAT WATER } R_{\text{MAHC}} \\
 & \quad + \\
 & \text{Area of AGITATED WATER in ft}^2 \times \text{AGITATED WATER } R_{\text{MAHC}} \\
 & \quad + \\
 & \text{Area of HOT WATER in ft}^2 \times \text{HOT WATER } R_{\text{MAHC}} \\
 & \quad + \\
 & \text{Area of DECK in ft}^2 \times \text{DECK } R_{\text{MAHC}} \\
 & \quad + \\
 & \text{Area of Stadium Seating in ft}^2 \times \text{Stadium Seating } R_{\text{MAHC}} \\
 & \quad = \\
 & \text{Total cfm of required outdoor air for INDOOR AQUATIC FACILITY}
 \end{aligned}$$

Appendix 2 Table above was established to provide a guide for designers to achieve acceptable air quality while considering the main factors that affect air quality:

Water treatment, BATHER LOAD, and water surface area (splashing, aeration). The following outlines the discussion by the Technical Committee. One of the goals was to establish a more comprehensive formula than is currently published in the ASHRAE 62 ventilation document (e.g., adding additional air requirements to the minimum ASHRAE STANDARDS). The formula should include consideration for the type of feature as well as what type of water treatment is being utilized to maintain the water chemistry. The Technical Committee realized early on that there is very little research in the off-gassing of chemicals for INDOOR AQUATIC FACILITIES. ASHRAE completed a preliminary research project⁵¹⁴ but did not perform detailed research on various AQUATIC VENUES and treatment methods. The committee had to use the experience of its members on what was working in the real world and what was not working to modify the formula used in ASHRAE 62. In other words, the committee had the final answer and developed a

⁵¹⁴ Cavestri, RC, Seeger-Clevenger, D. Chemical off-gassing from indoor swimming pools [Internet]. Dublin (OH): American Society of Heating, Refrigerating, and Air Conditioning Engineers; 2008 Ju [cited 2011 Mar 3]. 40 p. Available from: <http://rp.ashrae.biz/page/RP1083.pdf>

modified formula that yielded the desired results. This formula calculated the minimum air required in ASHRAE 62 and then added additional air TURNOVER requirements depending on the type and area of AQUATIC FEATURE or DECK/spectator area.

The matrix was set up with three types of AQUATIC VENUES: FLAT WATER, AGITATED WATER, and HOT WATER as each type of AQUATIC VENUE differs in how it affects air quality. One of the key drivers that the Technical Committee identified that made these AQUATIC VENUES different was the expected BATHER LOADING density. With increased BATHERS per unit volume of water there is an increase in the organic contamination from the POOL users and thus the presence of combined CHLORINE or combined bromine. The second factor was how much surface area of the AQUATIC VENUE water would come in contact with the air to increase the expected off-gassing of chemicals.

The rationale for developing guidance related to density and AQUATIC VENUE types is as follows:

4. FLAT WATER
 - a. Contribute to poor air quality only when there are BATHERS splashing, releasing TRICHLORAMINE and other DBPs into the air.
 - b. These AQUATIC VENUES generally are for swimming
 - c. The density was established at 20 ft² per person. This represents an average horizontal swimmer occupying a 5ft by 4ft area.
 - d. Assuming a person is swimming horizontally; a full body length is an average 5 ft with a 5 ft SPAN to equal 25 ft². There was a need to account for higher density in shallow areas where users waded vertically versus swim horizontally. The middle ground was decided to be 20 ft².
5. AGITATED WATER
 - a. These are AQUATIC VENUES with AQUATIC FEATURES that mechanically disturb the water surface such as spray features, waterslides, etc. They contribute to poor air quality any time those AQUATIC FEATURES are operating. This constant introduction of DBPs into the air requires more fresh air for these venues.
 - b. These AQUATIC VENUES generally are for wading and enjoyment of features without swimming
 - c. The density was established at 15 ft² per person. This represents an average vertical user occupying a 5ft by 3ft area. This also complies with the Illinois State POOL Code.
6. HOT WATER
 - a. These AQUATIC VENUES require more chemicals and release more DBPs due to increased chemical demand, increased introduction of BATHER waste, and increased evaporation, which deposits more DBPs into the air per square foot than any other AQUATIC VENUE. This type of features requires the most outside air.
 - b. These AQUATIC VENUES generally are for lounging such as hot tubs, warming POOLS, etc.
 - c. The density was established at 10 ft² per person. This represents an average user sitting in a 3ft by 3ft area.

7. DECK and Spectator Areas

- a. For leisure POOLS, one can assume 50 ft² per person based on Illinois POOL code. Adding seating and tables, which separates groups, the square footage allows for less density.
- b. For spectator area, the committee used 6.6 ft² per person for stadium seating from the ASHRAE 62.1 Table. This seating is generally well above the water level.

Using the ASHRAE 62.1 definitions for outside air as a baseline and utilizing the ASHRAE method to determine minimum outside air requirements plus adding additional fresh air depending on feature type from Appendix 2 Table, the formula is:

Minimum outside air in cfm = ($R_a \times \text{AQUATIC VENUE and DECK area in ft}^2$) + ($\text{AQUATIC VENUE A area in ft}^2 \times (R_p / \text{Density factor})$) + ($\text{AQUATIC VENUE B area in ft}^2 \times (R_p / \text{Density})$) + ($\text{DECK area in ft}^2 \times (R_p / \text{Density factor})$) + ($R_a \times \text{Spectator area in ft}^2$) + ($\text{Spectator area in ft}^2 \times (R_p / \text{Density factor})$)

- R_a = cfm of outside air needed for an aquatic space of any type without PATRONS. Using factor from ASHRAE 62.1 See Appendix 2 Table for R_a value
- R_p = additional cfm needed per person occupying the AQUATIC VENUE above that calculated with R_a and ASHRAE 62.1. R_p value is based on type of AQUATIC VENUE for reasons stated above. See Appendix 2 Table for appropriate R_p value.
- R_p = additional cfm needed per person occupying DECK or spectator space above that calculated with R_a and ASHRAE 62.1. Occupant density differs based on DECK or spectator usage. See Appendix 2 Table for appropriate R_p value.

This calculation allows for calculating minimum outside air required for an AQUATIC FACILITY that has varying sizes and types of AQUATIC VENUES. Engineers can calculate for individual AQUATIC VENUES and DECK spaces and add them together for the entire facility.

Design professionals experience factored into the final cfm/ft². Design professionals knew from experience where the final number needed to be, added in reasonable density factors and then addressed the individual characteristics of the AQUATIC VENUES to include splashing at the surface and the temperature of the water.

To calculate the minimum cfm of fresh air required:

Minimum number of cfm of fresh air for AQUATIC FACILITY by type =

$(R_a \times \text{AQUATIC VENUE and DECK area in ft}^2) + (\text{AQUATIC VENUE A area in ft}^2 \times (R_p / \text{Density factor})) + (\text{AQUATIC VENUE B area in ft}^2 \times (R_p / \text{Density})) + (\text{DECK area in ft}^2 \times (R_p / \text{Density factor})) + (R_a \times \text{Spectator area in ft}^2) + (\text{Spectator area in ft}^2 \times (R_p / \text{Density factor}))$

Example 1: Aquatic Facility with Flat Water Feature

Aquatic Venue	Area (ft²)	Fresh Air Required (cfm)
<i>Deck Minimum</i>	30,000	14,400
<i>Water=Flat</i>	15,000	7,500
<i>Water=Agitated</i>	0	0
<i>Water=Hot</i>	0	0
<i>Deck Area Only</i>	15,000	3,000
	Feature Area Subtotal	24,900
Total cfm/ft² feature/deck area		0.83

Aquatic Venue	Area (ft²)	Fresh Air Required (cfm)
<i>Spectator Area minimum</i>	6,500	390
<i>Spectator additional</i>	6,500	7,386
Total cfm		32,676
Total cfm/ft² w/ spectator area		0.90

Example 2: Aquatic Facility with Agitated and Hot Water Venues

Aquatic Venue	Area (ft²)	Fresh Air Required (cfm)
<i>Deck Area</i>	60,000	28,800
<i>Water=Flat</i>	0	0
<i>Water=Agitated</i>	25,000	41,667
<i>Water=Hot</i>	2,000	12,000
<i>Deck Area Only</i>	33,000	6,600
	Pool Area Subtotal	89,067
Total cfm/ ft² pool/deck area		1.48

Aquatic Venue	Area (ft²)	Fresh Air Required (cfm)
<i>Spectator area minimum</i>	2,500	150
<i>Spectator area additional</i>	2,500	2,841
Total cfm		92,058
Total cfm/ ft² w/ spectator area		1.47

Appendix 3: Dye Test Procedure

Dye testing should be performed to determine and adjust the performance of the RECIRCULATION SYSTEM. Dye studies tend to be qualitative in nature.⁵¹⁵

Some judgment is generally required to determine whether a dye study should be classified as passing or a failing. In general, dead zones (or areas of poor circulation) would indicate a failure that could be fixed by adjusting the INLETS or other system hydraulics. If the POOL does not reach a uniform color within 15 minutes, then adjustments are required.

Materials

- Crystal violet ($C_{25}N_3H_{30}Cl$) (20 g/ 50,000 gal)
- Sodium thiosulfate penta-hydrate ($Na_2S_2O_3 \cdot 5H_2O$) (1.2 oz/ 1 ppm FC/ 10,000 gal)
- Sodium hypochlorite (Bleach 5.7% available CHLORINE) (6.64 L/ 50,000 gal)
- Two containers (20 L or 5 gal)
- Video camera
- Photo camera (optional)
- Tripod
- CHLORINE detection kit
- Pump (capable of 700 mL/min or 0.18 gpm)
- Tubing (~6.4 mm or 1/4 inch ID)
- Tubing clamps
- Fittings, adapters, and Teflon tape (for threaded connections)
- Scale
- Gloves
- Timer

Procedure

1. Use a scale to weigh out the correct amount of crystal violet needed. Be sure to wear proper safety equipment when handling any chemicals.
2. Make the stock crystal violet solution by mixing the crystal violet and three gallons of non-chlorinated water in a container.
3. If you do not plan to use the POOLS existing DISINFECTION system during the dye removal process, then it will be necessary to prepare a sodium hypochlorite solution. To do this follow the recommend dose of 6.64 liters of bleach (5.7% available CHLORINE) per 50,000 gallons of POOL water. Place the correct amount into a separate container.

⁵¹⁵ Alberta. Pool Standards, 2006 for the Swimming Pool, WADING POOL, and Water Spray Park Regulation. (Last accessed 1/1/2011). <http://www.health.alberta.ca/documents/Standards-Pools.pdf>

4. Two days prior to the dye study cut off the POOL's DISINFECTION system, and then measure the CHLORINE concentration of the POOL. On the same day as the DISINFECTION system is turned off, weigh out enough sodium thiosulfate pentahydrate to neutralize the CHLORINE that is present and dump it around the perimeter of the POOL. It is necessary to neutralize the CHLORINE because it will react with the dye. Come back the following day to make sure there is no CHLORINE, and likewise on the day of the dye study.
5. Prepare the pump by attaching the tubing to the existing piping and calibrate the flow rate to 700 mL/min. At this flow rate, the stock solution of dye will be injected into the POOL over a 16 minute period. Tube clamps may be used to secure the connection between the tubing and the connectors.
6. Prepare the filter room by laying down a trash bag (or similar item) as protection from a potential chemical spill/leak. Then place the pump and containers containing the dye stock solution and sodium hypochlorite solution on the plastic cover.
7. Prepare a location in the pipe network (preferably after the filter) to inject the chemicals. If a location does not already exist (e.g., an existing CHLORINE feed or acid feed point) then one will need to be made by tapping the pipe and inserting the proper fitting.
8. Attach the tubing from the pump to the existing or newly created injection point. Depending on what fitting is present you might need an adapter for the tubing. The other end of the tubing should be placed in the chemical container holding the dye.
9. Make sure all assistants are in place to record video, take pictures, collect data, and time injection to 15 minute pass/fail observation point.
10. When ready to start, turn on the pump. The dye should begin to flow into the POOL. Start the timer at the same time as the pump is turned on (pump on, time (t) = 0 min). The stock dye solution should be depleted in 16 minutes. After 16 minutes, turn the pump off so that air will not be introduced into the system.
11. Record the time when the dye is first observed coming into the POOL.
12. Record the time when the POOL water is completely dyed (having uniform color).
 - a. *Most POOLS should be uniformly dyed within 15-20 minutes (and generally no more than 30 minutes) when the RECIRCULATION SYSTEM is hydraulically balanced.*
13. Record any observations or patterns, including dead spots and/or short circuiting, and the corresponding times that they were noticed throughout the test.
 - a. *Adjustments should be made to the RECIRCULATION SYSTEM to correct for any problems observed. Adjustments could include the following:*
 - i. *the direction of INLETS (up and down as well as left and right),*
 - ii. *the velocity of water through the INLETS (when adjustable by INLET modification or TURNOVER time adjustment), and*
 - iii. *the proportion of water from the surface overflow and main drain components of the RECIRCULATION SYSTEM.*
14. Remove the dye by re-chlorinating the POOL. Switch the tubing from the container of dye to the one containing the sodium hypochlorite and turn the pump back on. Another option would be to restart the POOL's current DISINFECTION system.

Observe and record what you see as the dye is removed from the POOL through chlorination.

DRAFT