

**M14**

# Backflow Prevention and Cross-Connection Control **Recommended Practices**

Fifth Edition



American Water Works  
Association

# Backflow Prevention and Cross-Connection Control Recommended Practices

Fifth Edition



American Water Works  
Association

Manual of Water Supply Practices—M14, Fifth Edition

## Backflow Prevention and Cross-Connection Control: Recommended Practice

Copyright © 1973, 1989, 2015, 2024 American Water Works Association

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including scanning, recording, or any information or retrieval system. Reproduction and commercial use of this material is prohibited, except with written permission from the publisher.

### Disclaimer

The authors, contributors, editors, and publisher do not assume responsibility for the validity of the content or any consequences of their use. In no event will AWWA be liable for direct, indirect, special, incidental, or consequential damages arising out of the use of information presented in this book. In particular, AWWA will not be responsible for any costs, including, but not limited to, those incurred as a result of lost revenue. In no event shall AWWA's liability exceed the amount paid for the purchase of this book.

Senior Editorial Manager – Book Products: Melissa Valentine  
Senior Manuals Specialist: Molly Beach  
Manager – Publishing Operations: Gillian Wink  
Technical Editor: Suzanne Snyder  
Copyright and Permissions Manager: Peggy Tyler  
Cover Composition/Technical Illustrations: Michael Labruyere  
Production: Innodata  
Cover Image: wacomka/Shutterstock.com

---

### Library of Congress Cataloging-in-Publication Data

Names: LeBas, Mitch, editor.

Title: M14 - backflow prevention and cross-connection control : recommended practices / [edited] by Mitch LeBas.

Other titles: Recommended practices for backflow prevention and cross-connection control | Backflow prevention and cross-connection control : recommended practices

Description: Fifth edition. | Denver, CO : American Water Works Association, [2024] | Includes bibliographical references and index. | Summary: "The purpose of this manual is to educate and inform interested backflow prevention and cross-connection control program managers and administrators about the most current practices; to explore advantages and disadvantages of various policies regarding backflow prevention programs; and to provide thoughtful and meaningful topics for consideration when developing, implementing, and managing programs"-- Provided by publisher.

LCCN 2023018351 (print) | LCCN 2023018352 (ebook) | ISBN 9781647171087 (paperback) | ISBN 9781613006412 (adobe pdf)

Subjects: LCSH: Backsiphonage (Plumbing)--Prevention. | Cross-connections (Plumbing)

Classification: LCC TH6523 .R43 2024 (print) | LCC TH6523 (ebook) | DDC 696/.1--dc23/eng/20230427

LC record available at <https://lcn.loc.gov/2023018351>

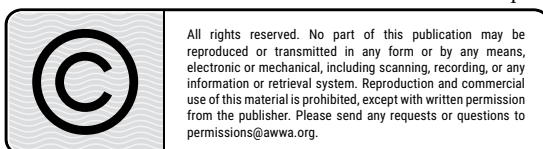
LC ebook record available at <https://lcn.loc.gov/2023018352>

Printed in the United States of America

ISBN: 978-1-64717-108-7

ISBN, electronic: 978-1-61300-641-2

<https://doi.org/10.12999/AWWA.M14ed5>



**American Water Works  
Association**

American Water Works Association  
6666 West Quincy Avenue  
Denver, CO 80235-3098  
[awwa.org](http://awwa.org)

# Contents

<b>List of Figures, v</b>	
<b>List of Tables, ix</b>	
<b>Preface, xi</b>	
<b>Acknowledgments, xiii</b>	
<b>Metric Conversions, xv</b>	
<b>Chapter 1 Introduction . . . . .</b>	<b>1</b>
Purpose of Manual, 2	
Safe Drinking Water Act, 2	
Public Water System Responsibilities, 4	
Protecting the Public Health (Program Implementation), 5	
Public Health and Plumbing Codes, 10	
Public Health Parameters, 11	
Legal Aspects, 13	
References, 14	
<b>Chapter 2 Backflow Prevention Principles . . . . .</b>	<b>15</b>
Basic Hydraulics, 15	
Types of Backflow, 17	
Assessing other Risk Factors, 25	
Types of Assemblies and Devices, 26	
<b>Chapter 3 Cross-Connection Control Program Administration . . . . .</b>	<b>29</b>
Developing a Cross-Connection Control Program, 30	
Types of Cross-Connection Control Programs, 30	
Management Programs, 35	
Documentation, 39	
Human Resources, 40	
Program Administration, 41	
<b>Chapter 4 Backflow Prevention Assembly, Device, and Method: Application, Installation, and Maintenance . . . . .</b>	<b>49</b>
What is Used to Prevent Backflow, 50	
Backflow Prevention Devices, 50	
Dual Check Valve (DCV), 51	
Dual Check Valve With Atmospheric Vent (DCVWAV), 52	
Atmospheric Vacuum Breaker (AVB), 53	
Hose Bibb Vacuum Breaker (HBVB), 54	
Backflow Prevention Assemblies (Specification, Requirements, and Guidelines), 54	
The Following Applies to Reduced Pressure Principle Backflow Prevention Assemblies Only, 56	
Pressure Vacuum Breaker Assembly (PVB), 57	
Spill-Resistant Pressure Vacuum Breaker (SRPVB), 60	

	Double Check Valve Backflow Prevention Assembly (DCVA), 61	
	Reduced-Pressure Principle Backflow Prevention Assembly (RP), 64	
	Double Check Detector Backflow Prevention Assembly (DCDA), 68	
	Reduced-Pressure Principle Detector Backflow Prevention Assembly (RPDA), 69	
	Controlling Backflow—Nonmechanical Separation Method, 71	
	Field-Testing, 73	
	Reference, 75	
<b>Chapter 5</b>	<b>Cross-Connection Control Survey</b> . . . . .	<b>77</b>
	Purpose of a Cross-Connection Control Survey, 78	
	Survey Considerations and Concepts, 79	
	Conducting the Survey, 82	
	Authority and Responsibilities, 87	
	References, 87	
<b>Chapter 6</b>	<b>Sample Hazards and Proper Protection</b> . . . . .	<b>89</b>
	Typical Hazards, 90	
	Hazards Posed by a Water Supplier, 98	
	Protection for Specific Customers, 103	
	References, 106	
<b>Appendix A</b>	<b>Example Notices and Letters</b> . . . . .	<b>107</b>
<b>Appendix B</b>	<b>Testing Procedures or Methods</b> . . . . .	<b>113</b>
<b>Appendix C</b>	<b>Industry Resources</b> . . . . .	<b>225</b>
<b>Appendix D</b>	<b>Backflow Incident Case Histories</b> . . . . .	<b>227</b>
	<b>Glossary</b> , 231	
	<b>Index</b> , 239	
	<b>List of AWWA Manuals</b> , 243	

# Figures

- 1-1 Illustration of protective devices and a dedicated line for potable water, 6
- 1-2 Location on private side of property line, 7
- 1-3 Location on public entity side of property line, 8
- 1-4 Commercial property with fire protection system, 9
- 2-1a Example of barometric loop in a piping configuration, 16
- 2-1b Example of barometric loop outside building, 17
- 2-2 Backsiphonage backflow due to high rate of water withdrawal, 19
- 2-3 Backpressure backflow caused by carbon dioxide cylinder, 21
- 2-4 Backpressure backflow caused by pumping system, 22
- 2-5 Backsiphonage backflow caused by reduced pressure on suction side of booster pump, 23
- 2-6 Backsiphonage backflow caused by shutdown of water system, 24
- 4-1 Dual check valve, 51
- 4-2 Dual check valve with atmospheric port (vent), 52
- 4-3 Atmospheric vacuum breaker, 53
- 4-4 Hose bibb vacuum breaker, 54
- 4-5 Pressure vacuum breaker assembly—flow condition, 58
- 4-6 Pressure vacuum breaker assembly—backsiphonage condition, 59
- 4-7 Spill-resistant pressure vacuum breaker—normal flow and backsiphonage conditions, 60
- 4-8 Double check valve assembly—flow check valves open, 61
- 4-9 Double check valve assembly—backpressure with both check valves closed, 62
- 4-10 Double check valve assembly—subatmospheric supply pressure—check valves closed, 62
- 4-11 Typical double check valve assembly—applications, 63
- 4-12 Reduced-pressure principle backflow prevention assembly, both check valves open and the differential pressure relief valve closed, 64
- 4-13 Both check valves closed and the differential pressure relief valve open, 65
- 4-14 Backpressure: both check valves closed and the differential pressure relief valve closed, 65
- 4-15 Backsiphonage: both check valves closed and the differential pressure relief valve open, 66
- 4-16 Typical reduced-pressure principle backflow prevention applications, 67
- 4-17 Double check detector backflow prevention assembly, 67
- 4-18 Type II double check detector backflow prevention assembly, 68
- 4-19 Reduced pressure principle detector backflow prevention assembly, 69
- 4-20 Type II reduced pressure principle detector backflow prevention assembly, 70
- 4-21 Air gap on tank, 71

- 4-22 Air gap on lavatory, 72
- 4-23 Typical air gap applications, 72
- 4-24 Additional typical air gap applications, 73
- 5-1 Internal plumbing controlled pursuant to plumbing code and containment assembly used for process water, 80
- 5-2 Service line backflow prevention assembly installed pursuant to statute, internal plumbing controlled pursuant to plumbing code, and containment assembly used for process water, 80
- 5-3 Internal plumbing controlled pursuant to plumbing code and containment assembly used for process water and fire system, 81
- 5-4 Service line backflow prevention assembly installed pursuant to statute, internal plumbing controlled pursuant to plumbing code, and containment assembly used for process water and fire system, 81
- 6-1 Cross-connection control, water treatment plants, 102
- 6-2 Service-containment and area-isolation water treatment plants, 102
- B-1 Double check valve assembly, 114
- B-2 No backpressure, 115
- B-3 Backpressure conditions, 116
- B-4 DCVA—first check valve differential pressure test step #2, 117
- B-5 DCVA—second check valve differential pressure test step #3, 119
- B-6 DCVA—No-flow tightness validation test step #4, 121
- B-7 Reduces pressure principle backflow prevention device assembly, 123
- B-8a RPZ—Step #1, drip tight
- B-8b RPZ—Step #1, not drip tight, 126
- B-9 RPZ—First check valve differential pressure test step #1A, 129
- B-10 RPZ—Second check valve tightness test step #2, 130
- B-11 RPZ—No-flow tightness validation test Step #3, 132
- B-12 RPZ—Relief valve opening point step #4, 134
- B-13 RPZ—Second check valve differential pressure test step #5, 135
- B-14 Tee fitting, 136
- B-15 Tee fitting connection test cock #4, 137
- B-16 Bypass hose connection, 137
- B-17 RPZ—Relief valve opening point with tee fitting, 139
- B-18 Pressure vacuum breaker, 139
- B-19 PVB—Check valve differential pressure measurement step #1, 141
- B-20 PVB—No-flow tightness validation test step #2, 142
- B-21 PVB air inlet valve test step #3, 143
- B-22 PVB—Air inlet valve test leaking upstream shutoff valve step #3A, 145
- B-23 Spill-resistant pressure vacuum breaker, 147
- B-24 SRPVB—No-flow tightness validation test step #1, 148
- B-25 SRPVB—Check valve differential pressure measurement step #2, 150
- B-26 SRPVB—Air inlet valve opening point step #3, 151
- B-27 Compensating bleed-off valve, 153

- B-28 SRPVB—Check valve differential pressure measurement leaking upstream shutoff valve step #2A, 153
- B-29 SRPVB—Air inlet valve opening point leaking upstream shutoff valve step #3A, 155
- B-30 NEWWA backflow prevention device assembly test report form, 157
- B-31 Sample test report form, 163
- B-32 Ground wire installation, 164
- B-33 Ground wire installation, 165
- B-34 Major component parts of five-valve differential pressure gauge test equipment, 177
- B-35 Differential pressure gauge test kit, five-valve model, 178
- B-36 Differential pressure gauge showing hose connections to test the components of an RPBA, 179
- B-37 Differential pressure gauge showing hose connections to test the #1 check valve of a DCVA, 180
- B-38 Differential pressure gauge showing hose connections to test a PVBA air inlet, 180
- B-39 Pressure gauge showing hose connections to test a PVBA check valve, 181
- B-40 Differential pressure gauge showing hose connections to test both the check valve and air inlet of an SVBA, 181
- B-41 Test 1—CV #1, 213
- B-42 Test 3—CV #2, 214
- B-43 Two-valve differential pressure test kit, 217
- B-44 Two-valve test kit, 218
- B-45 Three-valve test kit, 221
- B-46 Reduced-pressure field test with three-valve test kit, 223



This page intentionally blank.

# Tables



- 2-1 Means of backflow prevention in the United States, 27
- 2-2 Selection guide for backflow preventers in Canada (See Clauses 5.3.1.1 and 5.4.1), 27
- 6-1 Recommended protection for solar domestic hot-water systems, 98
- 6-2 Recommended protection at fixtures and equipment found in water treatment plants, 101
- 6-3 For containment, 103
- 6-4 Containment protection, 104
- 6-5 Typical backflow devices, 104
- 6-6 Irrigation and hose connection protection, 104
- 6-7 Means of backflow prevention in Canada (pending permission) (see Clauses 5.3.1.1 and 5.4.1), 105

This page intentionally blank.

# Preface



A dedicated group of volunteers from the Cross-Connection Control Committee of the American Water Works Association (AWWA) dedicated countless hours preparing the revisions to this manual of practice. This publication is the fifth edition of AWWA Manual M14, *Backflow Prevention and Cross-Connection Control: Recommended Practices*, originally published in 1973. We encourage interested readers to pursue additional information on backflow prevention–related topics through other AWWA resources.

The purpose of this manual is to educate and inform interested backflow prevention and cross-connection control program managers and administrators about the most current practices; explore advantages and disadvantages of various policies regarding backflow prevention programs; and provide thoughtful and meaningful topics for consideration when developing, implementing, and managing programs. This manual is not intended to be a reference for governmental codes, laws, or regulations or to be used as a training manual. However, the committee recognizes that the manual is used for such purposes on occasion due to the knowledge and expertise of the committee members, past and present, who have contributed to this manual. The manual is designed to provide the user with an understanding of cross-connection control and backflow prevention.

The manual commences with the explanation of basic concepts within the industry, explores means and methods of preventing backflow, addresses backflow prevention practices, and provides guidance for implementing backflow prevention and cross-connection control programs to both the novice and experienced program manager.

Revisions to the fifth edition were made throughout the manual; however, previous users of the manual may notice that significant effort was afforded to revising Chapters 3 and 5. The primary goal of this effort was to provide thought-provoking content to enable program managers to achieve greater success within their program. New manual users will benefit from the expanded historical content added to Chapter 1.

It is the intent of the Cross-Connection Control Committee that users will obtain knowledge of the industry and that the manual will be a valuable tool for use in implementing an effective cross-connection control program to protect public health. The Cross-Connection Control Committee and AWWA welcome your comments and suggestions for improving future editions of this manual. Please send an email to [ets@awwa.org](mailto:ets@awwa.org) to provide feedback on the contents of this manual.

Mitch LeBas, PE  
Chair

This page intentionally blank.

# Acknowledgments

The AWWA Distribution & Plant Operations Division gratefully acknowledges the contributions made by those volunteers who drafted, edited, and provided the significant and critical commentary essential to updating AWWA Manual M14. The Steering Committee members dedicated numerous hours in the final stages of preparation of this edition to ensure the overall technical quality, consistency, and accuracy of the manual.

## **Steering Committee Members**

Mitch LeBas, Chair, Backflow Prevention Services, LLC, Baton Rouge, La.  
Steve Fox, South Carolina Department of Health & Environmental Control, Columbia, S.C.  
Kristy McAndrew, Charles County Government, La Plata, Md.  
Jim Siriano, The Cadmus Group, Denver, Colo. (former AWWA staff member)

## **Contributors to the 5th Edition**

Stuart F. Asay, Backflow Prevention Institute IAPMO, Westminster, Colo.  
Roland Asp, National Fire Sprinkler Association, Inc., Linthicum Heights, Md.  
Troy Baird, Bac-Flo Unlimited, Inc., Boerne, Tex.  
Benjamin Bennett, Backflow Prevention Specialists, Inc., Sunnyvale, Calif.  
Sylvain Boudrias, Darspec Engineers & Experts, Brossard, Quebec, Canada  
Al Fuentes, Jr., Texas Commission on Environmental Quality, Austin, Tex.  
Steven Garner, California-Nevada Section AWWA, West Sacramento, Calif.  
John Graham, California Water Service Company, Chico, Calif.  
Chris Haldiman, Watts, North Andover, Md.  
David Hale, Engineer, American Water Works Association, Denver, Colo.  
Byron Hardin, Hardin & Associates Consulting, LLC, Carrollton, Tex.  
Joanie Hartley, City of Raleigh, Raleigh, N.C.  
James Holeva, NEWWA Representative, Holliston, Mass.  
Mark Krouse, Charlotte Water, Charlotte, N.C.  
Paul Patterson, HydroCorp, Inc., Troy, Mich.  
Ken Payne, San Francisco Public Utilities, Commission, Burlingame, Calif.  
Vijay Ratnaparkhe, City of Toronto, Toronto, Canada  
Paul Schwartz, Los Angeles, Calif.  
Carolyn Stewart, Township of Langley, British Columbia, Canada  
Will Willis, Louisville Water, City of Louisville, Ky.  
Kyle Wong, Sammamish Plateau Water/Sewer District, Sammamish, Wash.  
Eric Yeggy, Water Quality Association, Lisle, Ill.

## **AWWA Policy Statement on Cross-Connection**

The American Water Works Association (AWWA) recognizes water utilities have the responsibility to supply potable water to their customers. In the exercise of this responsibility, water utilities or other responsible authorities must implement, administer, and maintain ongoing backflow prevention and cross-connection control programs to prevent backflow; protect public water systems from the hazards originating on the premises of their customers, such as the interface

between water systems and fire prevention/control systems; and protect public water systems from temporary connections that may impair or alter the water.

The return of any water to the public water system after the water has been used for any purpose on the customer's premises or within the customer's plumbing system is unacceptable and opposed by AWWA.

Water utilities or other responsible authorities should assure that effective backflow prevention measures are implemented commensurate with the degree of potential hazard and likelihood of occurrence to ensure protection of the water in public water distribution systems. Customers, together with authorities, are responsible for preventing contamination of the public water supply due to cross-connections with their plumbing systems and for maintaining associated backflow prevention devices.

If appropriate backflow prevention measures have not been taken, water utilities or other responsible authorities should take or initiate reasonable measures to ensure that public water distribution systems are protected from actual or potential backflow hazards. These measures could include the testing, installation, and assurance of proper operation and installation of backflow prevention assemblies, devices, and methods commensurate with the degree of hazard and likelihood of occurrence at the service connection, point of use, or both. If these actions are not taken, water utilities should be empowered to suspend service.

To reduce the risk customer plumbing systems pose to the public water distribution system, water utilities' backflow prevention programs should include public education and coordination with the cross-connection efforts of local authorities, particularly public health and plumbing officials. This is of increasing importance given the growing application of dual plumbing systems utilizing recycled water. In areas lacking a health or plumbing enforcement agency, water utilities should additionally promote the design and maintenance of customer plumbing systems for health and safety and to protect their customers from backflow hazards.

Practices specified in this policy statement are consistent with all other pertinent AWWA policy statements.

*Adopted by the Board of Directors Jan. 26, 1970, revised June 24, 1979, reaffirmed June 10, 1984, and revised Jan. 28, 1990, and Jan. 21, 2001, reaffirmed Jan. 16, 2005, revised Jan. 17, 2010, revised June 8, 2014, and revised Jan. 12, 2023.*

## METRIC CONVERSIONS

### Linear Measurement

inch (in)	×	25.4	=	millimeters (mm)
inch (in)	×	2.54	=	centimeters (cm)
foot (ft)	×	304.8	=	millimeters (mm)
foot (ft)	×	30.48	=	centimeters (cm)
foot (ft)	×	0.3048	=	meters (m)
yard (yd)	×	0.9144	=	meters (m)
mile (mi)	×	1,609.3	=	meters (m)
mile (mi)	×	1.6093	=	kilometers (km)
millimeter (mm)	×	0.03937	=	inches (in.)
centimeter (cm)	×	0.3937	=	inches (in.)
meter (m)	×	39.3701	=	inches (in.)
meter (m)	×	3.2808	=	feet (ft)
meter (m)	×	1.0936	=	yards (yd)
kilometer (km)	×	0.6214	=	miles (mi)

### Area Measurement

square meter (m <sup>2</sup> )	×	10,000	=	square centimeters (cm <sup>2</sup> )
hectare (ha)	×	10,000	=	square meters (m <sup>2</sup> )
square inch (in. <sup>2</sup> )	×	6.4516	=	square centimeters (cm <sup>2</sup> )
square foot (ft <sup>2</sup> )	×	0.092903	=	square meters (m <sup>2</sup> )
square yard (yd <sup>2</sup> )	×	0.8361	=	square meters (m <sup>2</sup> )
acre	×	0.004047	=	square kilometers (km <sup>2</sup> )
acre	×	0.4047	=	hectares (ha)
square mile (mi <sup>2</sup> )	×	2.59	=	square kilometers (km <sup>2</sup> )
square centimeter (cm <sup>2</sup> )	×	0.16	=	square inches (in. <sup>2</sup> )
square meter (m <sup>2</sup> )	×	10.7639	=	square feet (ft <sup>2</sup> )
square meter (m <sup>2</sup> )	×	1.1960	=	square yards (yd <sup>2</sup> )
hectare (ha)	×	2.471	=	acres
square kilometer (km <sup>2</sup> )	×	247.1054	=	acres
square kilometer (km <sup>2</sup> )	×	0.3861	=	square miles (mi <sup>2</sup> )

### Volume Measurement

cubic inch (in. <sup>3</sup> )	×	16.3871	=	cubic centimeters (cm <sup>3</sup> )
cubic foot (ft <sup>3</sup> )	×	28,317	=	cubic centimeters (cm <sup>3</sup> )
cubic foot (ft <sup>3</sup> )	×	0.028317	=	cubic meters (m <sup>3</sup> )
cubic foot (ft <sup>3</sup> )	×	28.317	=	liters (L)
cubic yard (yd <sup>3</sup> )	×	0.7646	=	cubic meters (m <sup>3</sup> )



This page intentionally blank.

Chapter **1**

# Introduction

The concern of maintaining safe drinking water is nothing new. Archeological studies reveal that as early as 3000 BC, the ancient Egyptian State had a government official who was required to inspect the country's water supply every 10 days. With the widespread use of water closets in the nineteenth century came direct cross-connections with water mains. These direct connections brought into focus a problem, as one nineteenth-century authority stated, "foul matters may get into the pipes."\*

Government and industry professionals are aware of the need to control cross-connections to help prevent contaminants from getting into the plumbing system and public water system. Public health officials are aware that improperly designed plumbing fixtures, as well as plumbing systems, can allow contaminants or pollutants to enter the plumbing system and ultimately be introduced into the public water system. This situation became evident when, in 1933, defective and improperly designed plumbing and fixtures caused an epidemic in Chicago. More than 1,400 cases of amebic dysentery and at least 98 deaths were traced to a waterborne outbreak. The City of Chicago and the US Public Health Service identified cross-connections at two hotels as a major cause of the outbreak (Gorman and Wolman 1939).

The need to protect public health by preventing contaminants and pollutants from entering the public water system or plumbing system is firmly established. According to the US Environmental Protection Agency (USEPA; 2001), cross-connections and backflow represent a significant public health risk. On March 14, 1928, the New England Water Works Association passed a resolution addressing cross-connections. The June 1928 issue of the *Journal of the New England Water Works Association* states, "The association strongly urges that states adopt suitable laws and regulations covering the control of cross-connections and that, in each community, an investigation of the existing cross-connections is made immediately, and a program for the control thereof be inaugurated by the local authorities. The Association recommends that where possible, the inspection be made through the cooperative efforts of state and municipal authorities on the one hand and owners and

---

\* A.J. Keenan, C.S.I., B.C. Section, AWWA Cross-Connection Control, September 1977.