



**American Water Works
Association**

ANSI/AWWA C104/A21.4-13
(Revision of ANSI/AWWA C104/A21.4-08)

AWWA Standard

Cement–Mortar Lining for Ductile-Iron Pipe and Fittings

Effective date: Oct. 1, 2013.

First edition approved by AWWA Board of Directors June 28, 1985.

This edition approved June 9, 2013.

Approved by American National Standards Institute Aug. 6, 2013.



AWWA Standard

This document is an American Water Works Association (AWWA) standard. It is not a specification. AWWA standards describe minimum requirements and do not contain all of the engineering and administrative information normally contained in specifications. The AWWA standards usually contain options that must be evaluated by the user of the standard. Until each optional feature is specified by the user, the product or service is not fully defined. AWWA publication of a standard does not constitute endorsement of any product or product type, nor does AWWA test, certify, or approve any product. The use of AWWA standards is entirely voluntary. This standard does not supersede or take precedence over or displace any applicable law, regulation, or codes of any governmental authority. AWWA standards are intended to represent a consensus of the water supply industry that the product described will provide satisfactory service. When AWWA revises or withdraws this standard, an official notice of action will be placed on the first page of the Official Notice section of *Journal - American Water Works Association*. The action becomes effective on the first day of the month following the month of *Journal - American Water Works Association* publication of the official notice.

American National Standard

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether that person has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review, and users are cautioned to obtain the latest editions. Producers of goods made in conformity with an American National Standard are encouraged to state on their own responsibility in advertising and promotional materials or on tags or labels that the goods are produced in conformity with particular American National Standards.

CAUTION NOTICE: The American National Standards Institute (ANSI) approval date on the front cover of this standard indicates completion of the ANSI approval process. This American National Standard may be revised or withdrawn at any time. ANSI procedures require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of ANSI approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036; (212) 642-4900, or emailing info@ansi.org.

ISBN-13, print: 978-1-58321-972-0

eISBN-13, electronic: 978-1-61300-250-6

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information or retrieval system, except in the form of brief excerpts or quotations for review purposes, without the written permission of the publisher.

Copyright © 2013 by American Water Works Association
Printed in USA

Committee Personnel

Subcommittee 4, Coatings and Linings, which reviewed and developed this revision, had the following personnel at the time:

L. Gregg Horn, *Chair*

General Interest Members

D.H. Kroon, Corrpro Companies Inc., Houston, Texas	(AWWA)
P.I. McGrath Jr., Consultant, Birmingham, Ala.	(AWWA)
J.R. Plattsmier, HDR Engineering Inc., Denver, Colo.	(AWWA)
E.S. Ralph,* Standards Engineer Liaison, AWWA, Denver, Colo.	(AWWA)
D.W. Russom, Russom Technical Services LLC, Vilonia, Ark.	(AWWA)
C.R. Schwenker, Malcolm Pirnie Inc., Arlington, Va.	(AWWA)
P.A. Selig, Consultant, Vestavia, Ala.	(AWWA)
K.E. Wilson, Atkins, Tampa, Fla.	(AWWA)

Producer Members

C. Comins, Custom Fab Inc., Orlando, Fla.	(AWWA)
J.H. Eddings, Atlantic States Cast Iron Pipe Company, Phillipsburg, N.J.	(AWWA)
M.D. Gaston, American Ductile Iron Pipe Company, Birmingham, Ala.	(AWWA)
L.G. Horn, Ductile Iron Pipe Research Association, Birmingham, Ala.	(AWWA)
A.M. Horton, US Pipe & Foundry Company, Birmingham, Ala.	(AWWA)
H. Kennedy Jr., Harold Kennedy & Associates, Fuquay Varina, N.C.	(AWWA)
V. O'Dea, Themec, Kansas City, Mo.	(AWWA)
G. Oliver,† American Cast Iron Pipe Company, Birmingham, Ala.	(AWWA)
L.C. Thompson, Specification Rubber Products, Alabaster, Ala.	(AWWA)
M.D. Wooten, Griffin Pipe Products Company, Lisle, Ill.	(AWWA)

User Members

D.T. Bradley, Oak Lodge Water District, Portland, Ore.	(AWWA)
M.J. Britch, Tualatin Valley Water District, Beaverton, Ore.	(AWWA)
J.M. Kennedy, Tampa Bay Water, Clearwater, Fla.	(AWWA)
R.L. Worden, COMCD, Norman, Okla.	(AWWA)

* Liaison, nonvoting

† Alternate

AWWA Standards Committee A21, Ductile-Iron Pipe and Fittings, which reviewed and approved this standard, had the following personnel at the time of approval:

John R. Plattsmier, *Chair*

General Interest Members

H.E. Holcomb, Consultant, Saint Marys, Ga.	(AWWA)
M.B. Horsley, Horsley Engineering LLC, Overland Park, Kan.	(AWWA)
D.H. Kroon, Corrpro Companies Inc., Houston, Texas	(AWWA)
D.D. Lary,* Wright-Pierce, Topsham, Maine	(NEWWA)
G.E. Laverick, Underwriters Laboratories Inc., Northbrook, Ill.	(AWWA)
P.I. McGrath Jr., Consultant, Birmingham, Ala.	(AWWA)
P.J. Mourt, Hatch Mott MacDonald, Milburn, N.J.	(AWWA)
J.R. Plattsmier, HDR Engineering Inc., Denver, Colo.	(AWWA)
E.S. Ralph,† Standards Engineer Liaison, AWWA, Denver, Colo.	(AWWA)
C.R. Schwenker, Malcolm Pirnie Inc., Arlington, Va.	(AWWA)
T.M. Stinson, Kleinfelder SEA Company, Cambridge, Mass.	(NEWWA)
L.C. Yates, McGoodwin Williams & Yates, Fayetteville, Ark.	(AWWA)

Producer Members

L.R. Dunn, US Pipe & Foundry Company, Birmingham, Ala.	(DIPRA)
J.H. Eddings, Atlantic States Cast Iron Pipe Company, Phillipsburg, N.J.	(AWWA)
M.D. Gaston, American Ductile Iron Pipe Company, Birmingham, Ala.	(AWWA)
L.G. Horn, Ductile Iron Pipe Research Association, Birmingham, Ala.	(AWWA)
M. Horton,* US Pipe & Foundry Company, Birmingham, Ala.	(DIPRA)
J.C. Jones, RCT, Los Angeles, Calif.	(AWWA)
H. Kennedy Jr., Harold Kennedy & Associates, Fuquay Varina, N.C.	(AWWA)
T.J. Muntz, Fab Pipe Inc., Rogers, Minn.	(AWWA)
G. Oliver,* American Cast Iron Pipe Company, Birmingham, Ala.	(AWWA)
M.D. Wooten, Griffin Pipe Products Company, Lisle, Ill.	(AWWA)

* Alternate

† Liaison, nonvoting

User Members

D.T. Bradley, Oak Lodge Water District, Portland, Ore.	(AWWA)
M.J. Britch, Tualatin Valley Water District, Beaverton, Ore.	(AWWA)
T.E. Coughran, City of La Habra, La Habra, Calif.	(AWWA)
A.J. DeBoy,* Indiana American Water, Greenwood, Ind.	(AWWA)
M.W. Griffin, American Water Company, Saint Louis, Mo.	(AWWA)
J.M. Kennedy, Tampa Bay Water, Clearwater, Fla.	(AWWA)
D.D. Montgomery, City of Independence, Independence, Mo.	(AWWA)
K.C. Morgan,† Standards Council Liaison, City of Phoenix Water Services Dept., Phoenix, Ariz.	(AWWA)
C.J. Patla, Connecticut Water Service Inc., Clinton, Conn.	(AWWA)
T.J. Roode, Denver Water, Denver, Colo.	(AWWA)
A. Shively, City of Kansas City, Kansas City, Mo.	(AWWA)
R.L. Worden, COMCD, Norman, Okla.	(AWWA)

* Alternate

† Liaison, nonvoting

This page intentionally blank.

Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

SEC.	PAGE	SEC.	PAGE
Foreword		4.2	Cement 3
I	Introduction..... ix	4.3	Sand..... 4
I.A	Background..... ix	4.4	Water 4
I.B	History..... ix	4.5	Mortar 4
I.C	Acceptance..... xi	4.6	Surface of Pipe and Fittings for Lining..... 4
II	Special Issues..... xii	4.7	Method of Lining..... 4
II.A	Use of Seal Coat..... xii	4.8	Thickness of Lining..... 4
II.B	Lining of Pipelines in Place xii	4.9	Determination of Thickness 5
III	Use of This Standard xii	4.10	Curing 5
III.A	Purchaser Options and Alternatives. xii	4.11	Lining Quality 5
III.B	Modification to Standard xiii	4.12	Seal Coat..... 6
IV	Major Revisions..... xiii	5	Verification
V	Comments xiii	5.1	Testing of Sand 6
Standard		5.2	Testing of Seal Coat 8
1	General	6	Delivery
1.1	Scope 1	6.1	Notice of Nonconformance..... 9
1.2	Purpose 1	6.2	Affidavit of Compliance 9
1.3	Application..... 1	Tables	
2	References 2	1	Minimum Thickness of Linings for Pipe and Fittings 5
3	Definitions 2	2	Requirements for Sand Tested With Standard Sieves 7
4	Requirements		
4.1	Materials 3		

This page intentionally blank.

Foreword

This foreword is for information only and is not a part of ANSI/AWWA C104/A21.4.*

I. Introduction.

I.A. *Background.* The first cast-iron water mains were not lined but were installed in the same condition in which they came from the molds following cleaning. After many years, it became evident that the interior of the pipe could be affected by certain types of water. The first lining used to combat aggressive waters was a hot-dip bituminous lining that protected the pipe satisfactorily, except in areas where water penetrated the pinholes in the bituminous lining, wherein tuberculation ensued. The need for a better lining to combat tuberculation led to experiments with cement mortar as a lining material.

Cement–mortar linings prevent tuberculation by creating a high pH at the pipe wall and ultimately by providing a physical barrier to the water. Cement–mortar linings are also smooth, which results in high flow coefficients.

In 1922, the first cement–mortar-lined, cast-iron pipe was installed in the water distribution system of Charleston, S.C. The pipe was lined in the field using a projectile drawn through the pipe. Since this initial installation, many improvements have been made in the production of cement–mortar-lined pipe. Cement–mortar-lined pipes are now centrifugally lined at the foundry to ensure that quality control is maintained and that a uniform thickness of mortar is distributed throughout the length of the pipe.

I.B. *History.* From 1922 to 1929, many installations of cement–mortar-lined, cast-iron pipe were made under various manufacturers' specifications. In 1929, the American Standards Association (ASA), now the American National Standards Institute (ANSI),* Committee A21 on Cast-Iron Pipe and Fittings, issued a tentative standard for cement–mortar linings, which was published by the American Water Works Association (AWWA) as a tentative standard in 1932. After many revisions and refinements, the standard was officially adopted by ASA in 1939 under the designation A21.4, American Standard Specifications for Cement–Mortar Lining for Cast-Iron Pipe and Fittings.

From 1940 to 1952, considerable research was done to improve the quality of the cement–mortar lining. The centrifugal process of lining was improved to provide the controls and techniques necessary to ensure uniformity of lining thickness throughout

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

the length of the pipe. Methods of curing cement mortar were investigated, resulting in the recognition that asphaltic seal-coat materials could be used as a substitute for the moist-curing process. As a result of this research, a revised edition of the 1939 standard was approved and issued in 1953.

In 1958, Committee A21 was reorganized and subcommittees were established to study each group of standards in accordance with ASA's review and revision policy. Subcommittee 4, Coatings and Linings for Cast-Iron Pipe, was organized to examine the existing ASA A21.4-53, American National Standard Specifications for Cement-Mortar Lining for Cast-Iron Pipe and Fittings. The subcommittee completed its study of A21.4-53 and submitted a proposed revision to Committee A21 in 1963. The revised third edition was approved and issued in 1964 and included a reduction in the minimum permissible thickness of lining. This reduction was based on more than 20 years of research by the Cast Iron Pipe Research Association (CIPRA), now the Ductile Iron Pipe Research Association (DIPRA), on experimental test lines having cement-mortar linings ranging from $\frac{1}{32}$ to $\frac{1}{4}$ in. (0.79 to 6.35 mm) in thickness and the assurance of uniformity of lining thickness using the centrifugal lining process. The 1964 revision also required the cement to meet the requirements of ASTM* C150, Specification for Portland Cement.

The next revision was issued in 1971. This revision incorporated a standard test for toxicity of the seal-coat material. The standard was again revised in 1974, and major changes to the section on lining quality were incorporated into this revision.

The 1980 revision to the standard included further changes to the section on lining quality, clarifying problems with some literal interpretations. Metric conversions of all dimensions and physical requirements were also included, and the projection method was added as an allowable means of lining pipe and fittings.

In the 1985 edition of the standard, all references to gray cast-iron pipe were deleted because gray cast-iron pipe was no longer being produced in the United States.

The 1990 revision of the standard included no major changes.

In 1995, the section on cement was expanded to include types of cement other than portland, and the size range covered by the standard was expanded to include 3-in. through 64-in. (76-mm through 1,600-mm) sizes. Additionally, the section on seal coat was revised to allow the manufacturer the option of providing the cement-mortar lining with or without a seal coat unless otherwise specified; the option of using seal-coat materials other than asphaltic was deleted.

* ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

In 2003, the format was changed to the current AWWA Standard Style. Sec. 4.7 on the thickness of lining and Sec. 4.8 on determination of thickness were revised to delete the requirement that the thickness shall be determined while the mortar is wet.

The next edition of ANSI/AWWA C104 was approved by the AWWA Board of Directors on June 8, 2008.

This edition was approved on June 9, 2013.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation, (formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.* Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on Apr. 7, 1990.
2. Specific policies of the state or local agency.
3. Two standards developed under the direction of NSF, NSF[†]/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.
4. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,[‡] and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdiction. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

* Persons outside the United States should contact the appropriate authority having jurisdiction.

† NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48106.

‡ Both publications available from National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20001.

Annex A, “Toxicology Review and Evaluation Procedures,” to NSF/ANSI 61 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of “unregulated contaminants” are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA C104 does not address additives requirements. Thus, users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.
2. Determine the status of certifications by parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

II. Special Issues.

II.A. *Use of Seal Coat.* Cement–mortar linings may be provided with or without a seal coat (Sec. 4.12.1). The purchaser of cement–mortar-lined pipe or fittings for use with water that is corrosive to cement, such as very soft water, should determine, by using the appropriate test, that a lining without a seal coat will not impart objectionable hardness or alkalinity to the water. The procedure outlined in Sec. 5.2.2.2, modified by the substitution of the water with which the pipe is to be used, is recommended. The concentration of leachates increases with the aggressiveness of the water and its residual time in the pipe and is indirectly proportional to the diameter of the pipe.

II.B. *Lining of Pipelines in Place.* This standard does not include provisions for cement–mortar lining of pipelines in place. Field lining of pipes is addressed in ANSI/AWWA C602.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. *Purchaser Options and Alternatives.* The following items should be provided by the purchaser:

1. Standard used—that is, ANSI/AWWA C104, Standard for Cement–Mortar Lining for Ductile-Iron Pipe and Fittings, of latest revision.
2. For applications other than potable water, whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, or alternatively FDA §175.300 of 21 CFR, is required (Sec. 4.1.2).
3. Details of other federal, state or provincial, and local requirements (Sec. 4.1).

4. Type of cement (Sec. 4.2).

5. Thickness of lining (Sec. 4.8). Two thicknesses of lining are available, and purchasers who require a lining thickness twice the standard thickness have the option of so specifying.

6. Seal coat requirements (Sec. 4.12). The purchaser has the option of specifying if the cement–mortar lining is to be provided with or without a seal coat.

7. Notice of Nonconformance (Sec. 6.1).

8. Request for an Affidavit of Compliance (Sec. 6.2).

III.B. *Modification to Standard.* Any modifications to the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. Major revisions made to the standard in this edition include the following:

1. Scope, purpose and application of standard were expanded to include raw water applications.

2. Addition of definitions for raw and potable water.

3. A new Sec. 4.1.2, Materials intended for use with potable water, was added to include a requirement for testing to NSF/ANSI 61 or FDA §175.300 of 21 CFR on products if they will be in contact with potable water.

4. The addition of a provision for manufacturers to use cement mortar that is a blend of ASTM C150 cement with ASTM C595 Type IS, or ASTM C989 cement, with the blend being no less than 50 percent ASTM C150 cement in Sec. 4.2.

V. Comments. If you have any comments or questions about this standard, please call AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603, write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098, or email at standards@awwa.org.

This page intentionally blank.



**American Water Works
Association**

ANSI/AWWA C104/A21.4-13
(Revision of ANSI/AWWA C104/A21.4-08)

AWWA Standard

Cement–Mortar Lining for Ductile-Iron Pipe and Fittings

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes shop-applied, cement–mortar linings specified in the ANSI*/AWWA C100/A21 series of standards for ductile-iron pipe and ductile-iron and gray-iron fittings for potable water, raw water, wastewater, and reclaimed water systems and is intended to be used as a supplement to those standards.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for shop-applied, cement–mortar linings for ductile-iron pipe and ductile-iron and gray-iron fittings for potable water, raw water, wastewater, and reclaimed water systems, including requirements for cement, sand, water, and mortar; surface of pipe and fittings for lining; method and thickness of lining; and curing.

Sec. 1.3 Application

This standard can be referenced in purchase documents for shop-applied, cement–mortar linings for ductile-iron pipe and fittings for potable water, raw water, wastewater, and reclaimed water systems. The stipulations of this standard apply

* American National Standards Institute, Inc., 25 West 43rd Street, Fourth Floor, New York, NY 10036.