ANSI/AWWA C228-19
(Revision of ANSI/AWWA C228-14)

American Water Works Association
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AWWA Standard

Stainless-Steel Pipe Flange Joints for Water Service—Sizes 2 In. Through 72 In. (50 mm Through 1,800 mm)

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American Water Works Association STANDARD Since 1881

Approved American National Standard ANSI

AWWA Standard

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Contents

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

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C228.*

I. Introduction.

I.A. *Background.* Stainless steel is a standard material used to construct piping and flanges. It offers very low corrosion rates, which makes it suitable for the handling of potable water while maintaining purity and quality.

I.B. *History.* In 1945, at the request of the American Society of Mechanical Engineers (ASME)†, a committee having representatives from both ASME and AWWA was formed. The ASME/AWWA committee was charged with establishing standards for steel flanges having dimensions and pressure ratings commensurate with the pressures commonly used in water service. The standards were necessary because the lowest pressure ratings for steel flanges at that time were those having cold-water pressure ratings of 275 psi (1,896 kPa) (ASME B16.5, Pipe Flanges and Flanged Fittings) or 150-psi (1,034-kPa) primary pressure ratings. The ratings were far higher than those ordinarily needed for water service.

Generally accepted practice for the design of bolted flange connections considers all fields of usage and a wide range of pressure and temperature applications. In waterworks practice, it is not necessary, within the scope of this standard, to deal with temperatures greater than the atmospheric range, and it is possible to limit the scope of consideration to gaskets contained in this standard and to flanges that are flat-faced. The designs were prepared in conformity with these limitations for carbon steel and first adopted in 1952. In 1999, AWWA developed a new standard for stainless-steel pipe, which then required a new standard for stainless-steel flanges.

In 1999, the AWWA Standards Council directed the Standards Committee on Steel Pipe to develop a standard for stainless-steel flanges used in water treatment and conveying facilities. In 2003, the Standards Council approved the formation of the Standards Committee on Stainless-Steel Pipe, which assumed responsibility for the development of this standard. The first edition of this standard was approved by the AWWA Board of Directors on Jan. 27, 2008. The last edition was approved on June 8, 2014. This edition was approved on Jan. 24, 2019.

The original ASME/AWWA committee gave careful consideration to the following: (1) the effect of new standards on existing equipment; (2) the fact that cast valves and

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
† ASME, Two Park Avenue, New York, NY 10016-5990.

fittings will always have flanges of large outside diameter, which cannot be reduced because of the wall thickness of this equipment; (3) the need for interchangeability of equipment through the use of common drilling patterns; and (4) the fact that standards could be based on the successful usage and good service records of existing installations.

A survey of water utility users indicated that it was desirable to maintain the outside diameter and drilling of flanged fittings and valves given in ANSI/AWWA C500, Gate Valves for Water and Sewerage Systems, and ANSI/ASME B16.1, Cast Iron Pipe Flanges and Flanged Fittings (for classes 25, 125, 250, and 800). The committee decided to follow this practice for sizes 6 in. through 48 in. (150 mm through 1,200 mm).

In its extensive deliberations, the ASME/AWWA committee had available the results of special research and testing conducted by ARMCO Steel Corporation, Bethlehem Steel Company, and Taylor Forge & Pipe Works. The various design methods and test results were given in *Steel Ring Flanges for Steel Pipe*, ARMCO Bulletin 47A (1947), from the American Rolling Mill Company, Middletown, Ohio. The design of flanges for waterworks service, with the results of the preceding report, was published in *Journal AWWA* in October 1950, pp. 931–939. A discussion in the paper by Taylor Forge & Pipe Works, participant in the ASME/AWWA committee, stated the reasons why a waterworks flange is not an ASME/Taylor Forge flange. Concern about high secondary stresses at the attachment, e.g., thick material to thin wall pipe, was covered there along with the published "Design of Wye Branches for Steel Pipe" (*Journal AWWA*, June 1955, appendix C, pp. 581–630).

Beginning in 2006, a special flange task group investigated development history of the flange dimensions found within the standard. After five years of research, the task group reached the following conclusions.

1. There is no one exact stress-based design method that could reproduce the thickness values in the standard tables. However, it appears that the ring flange thicknesses in this standard are based on using the LaTour-Barnard design procedure (ARMCO Bulletin 47A, 1947) for ring flanges, which is based on ASME integral flange design procedures.

2. A current design analysis was performed based on the LaTour-Barnard proposed design method (which was based on physical tests on pipes with steel ring flanges) that demonstrated comparable results. It is worthwhile to mention that the original LaTour-Barnard design procedure was a bending stress design methodology.

3. It has been established that flange thickness design based solely on a stress-based design procedure is incorrect. In R. Barnard's October 1950 *Journal AWWA* article, he wrote: "When the test results were analyzed, it became obvious

that the design formulas used in establishing American Standard flange dimensions predicted fantastically high localized stresses even when the joint assembly performed satisfactorily. Since a method of designing by test was being sought, a reconciliation of the apparent contradictions between theory and test results had to be explored. To find the answer, attention was turned to the behavior under load of the steel being tested in pipe wall and flange. Also, the stress factors in the formulas were further examined to discover whether or not a different concept of design would compose the apparent differences between theory and test results. It was found that theory fits the data when the concept of calculated stress level design is displaced by a concept of limiting-strain design. Then there was good correlation between theory, the test results, and past field experience and practice." Simply put, the design of flange thickness was performed as a limiting strain type of design procedure and not based on stress. The limiting strain was 5,000 µin./in. as determined by the 0.5 percent load extension method.

4. Many steel ring flanges have been supplied with thicknesses and dimensions that match the tables herein since these initial investigations were performed in the 1940s and 1950s by the ASME/AWWA committees leading up to the first edition of AWWA C207—Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm). As Barnard wrote in 1950, "the primary aim in flange design should be to prevent joint leakage since steel flange joints do not fail by fracture." The current flange task group has found this to be true over the past 60 years, as there have been no reported occurrences of steel flanges fracturing when servicing the pressure that they were supplied to meet.

5. The determination of the steel cylinder thickness at the flange attachment to be used in this standard is based on the design procedures for internal pressures shown in AWWA M11 *Steel Pipe: A Guide for Design and Installation*. This practice is deemed acceptable, based on empirical data of successful performance dating back to the early 1950s.

Tables 2 and 3 of the standard are based on historical dimensions and are presented without additional calculations.

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)

* NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) 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. Specific policies of the state or local agency.

2. 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.

3. 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 jurisdictions. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

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 C228 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.

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

† Both publications available from The National Academies Press, 500 Fifth Street NW, Keck 360, Washington, DC 20001.

II. Special Issues. Ring flanges included in this standard are for integral use on stainless-steel pipe only, and not for use as a loose backup flange. The thicknesses shown in the ring flange tables are based on the LaTour-Barnard analysis as presented in the *Steel Ring Flanges for Steel Pipe, ARMCO Bulletin 47A* (1947), and have been used successfully in the waterworks industry for more than 50 years. The flange thickness design using the LaTour-Barnard analysis is based on limiting flange stress to 22,500 psi (155 MPa) at the rated pressure. Thickness design of blind flanges has been based on the ASME Boiler and Pressure Vessel Code Design Method in Section VIII, Division 1, UG-34.

II.A. *Chlorine and Chloramine Degradation of Elastomers.* The selection of materials is critical for water service and distribution piping in locations where there is a possibility that elastomers will be in contact with chlorine or chloramines. Documented research has shown that elastomers such as gaskets, seals, valve seats, and encapsulations may be degraded when exposed to chlorine or chloramines. The impact of degradation is a function of the type of elastomeric material, chemical concentration, contact surface area, elastomer cross-section, environmental conditions as well as temperature. Careful selection of and specifications for elastomeric materials and the specifics of their application for each water system component should be considered to provide long-term usefulness and minimum degradation (swelling, loss of elasticity, or softening) of the elastomer specified.

II.B. *Gasket Degradation Study.* A pipe gasket, having the hardness of a compressed fiber with a large mass relative to the small exposed surfaced area, experiences minimal degradation. This was validated in a research paper published in *Journal AWWA*[*], where the pipe gasket degradation in a 110-mg/L chloramine solution was found to degrade just the exposed surface.

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 C228, Stainless-Steel Pipe Flange Joints for Water Service—Sizes 2 In. Through 72 In. (50 mm Through 1,800 mm), of latest edition.

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* Volume 96, Number 4, April 2004, pp. 153-160.

2. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, is required.

3. Details of other federal, state or provincial, and local requirements (Sec. 4.1.1).

4. Mill test certification (Sec. 4.1.3.5).

5. Class of flange required (Tables 2, 3, and 4).

6. Inside diameter of flanges (Tables 2 and 3).

7. Gaskets—elastomeric (rubber), compressed fiber (CFG), or polytetrafluoroethylene (PTFE)-based (Sec. 4.1.5) and gasket thickness.

8. Affidavit of compliance, if required (Sec. 6.2).

III.B. *Modification to Standard.* Any modification of 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. An advisory statement was added in the Foreword (Sec. II.A and II.B) regarding chlorine and choramine degradation of elastomers.

2. In Sec. 1.3.2 Pressure limits, the recommended transient pressure was changed from 125 percent of working pressure to 150 percent of working pressure to be consistent with limits given in ANSI/AWWA C207—Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).

3. The definitions in Sec. 3 for design pressure, field test pressure and transient pressure were revised for clarity and for consistency with the definitions in AWWA Manual M11 and the definition for potable water was added.

4. In Sec. 4.1.3.4 Minimum strength, Item 3 on dual-certified stainless steels was revised for clarity.

5. In Sec 4.1.4 Fasteners, second paragraph, the bolt lengths were changed from “plus ⅛ in.” to “plus ¼ in.” to better reflect field conditions, and a sentence on washer use was added.

6. Sec 4.1.5 Gaskets was revised. The term *rubber* was replaced with *elastomeric*; the reference to ASTM D1330 was removed; the maximum gasket seating stress for compressed fiber was revised; and a requirement for gaskets used for electrical isolation was added.

7. Table 1 was updated; the option of rubber gaskets for Class SB and SD flanges larger than 24 in. (600 mm) was deleted because of concerns of over-compressing the gasket; the term *rubber* was replaced with *elastomeric*; and Note 2 regarding insulation/isolation requirements was revised and the information moved to Sec. 4.1.5.

8. The maximum pressure (test or transient) allowed was revised from 125 percent to 150 percent of working pressure in Tables 2, 3, and 4.

9. The term Ra roughness average and a reference to ASME B46.1 was added to Sec. 4.2.2 Facing, for clarity.

10. A sentence was added to Sec 4.2.3 to Drilling to require the use of washers for oversized bolt holes.

11. In Sec. 4.2.4, Item 2, the term "100 percent" was added to clarify that radiographic or ultrasonic testing is 100 percent required for all welds.

12. Sec 4.3.1 Welding, was revised to reflect changes in Fig. 1 where "t" has been revised to "T_f" and "T_y" was added for the pipe cylinder thickness to clarify that for ¼ in. (6.4 mm) wall or smaller the weld size cannot be smaller than the cylinder wall.

13. The variable designations in Fig. 1 Attachment of flange, were revised to reflect the changes made in Sec. 4.3.1.

14. In Sec. 4.3.4, a sentence was modified to clarify that negative draft or layback is not permitted.

15. A new Fig. 3 was added to illustrate negative draft or layback.

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

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AWWA Standard

Stainless-Steel Pipe Flange Joints for Water Service—Sizes 2 In. Through 72 In. (50 mm Through 1,800 mm)

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes stainless-steel, ring-type, slip-on flanges and blind flanges for use in conjunction with stainless-steel pipe used in facilities of waterworks service.

Sec. 1.2 Purpose

The purpose of this standard is to provide minimum material requirements and dimensions for a variety of stainless-steel flanges for attachment to stainless-steel piping systems.

Sec. 1.3 Application

1.3.1 *Intended use*. Flanges in this standard are described in the following tables:

1. Table 2 and Table 3, ring-type slip-on flanges
2. Table 4, blind flanges

Flanges covered in this standard are intended for use with stainless-steel pipe or appurtenances meeting the requirements of ANSI/AWWA C220,