



## **THE UNI-BELL PVC PIPE ASSOCIATION'S GUIDE TO UNDERSTANDING THE AWWA C900-16 STANDARD**

**Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings,  
4 In. Through 60 In. (100mm Through 1,500 mm)**

### **ANSI/AWWA C900-16**

(Revision of ANSI/AWWA C900-07 and C905-10)

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**American Water Works  
Association**

# FOREWORD

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The PVC Pipe Association (PVCPIA) was formed in 1971 as the Uni-Bell PVC Pipe Association. The organization's mission includes:

- Conducting research and development
- Providing technical service and support
- Developing recommended standards
- Promoting proper use of PVC pipe

This document has been developed by the PVCPIA to assist PVC pipe specifiers and designers with the new AWWA C900-16 standard. This guide contains discussion of PVC pipe and fabricated fittings, including materials, products, and quality testing. Detailed discussion of pipe design parameters is included, along with a design example for cyclic surge pressures.





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Note: This guide is published by the PVC Pipe Association and has not been reviewed by AWWA



# 1.0

## INTRODUCTION

### HISTORY OF AWWA C900 AND C905 STANDARDS

AWWA C900-16 is the sixth edition of C900. The first edition was published in 1975; other editions followed in 1981, 1989, 1997, and 2007.

AWWA C905, which has been absorbed into C900-16, was first published in 1988; two subsequent editions occurred in 1997 and 2010.

### NEW EDITION OF AWWA C900 STANDARD

The new AWWA C900-16 standard, which became effective August 2016, is titled “Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 inch Through 60 inch.” This standard replaces the following:

- 1 AWWA C900-07 standard for sizes 4- through 12-inch
- 2 AWWA C905-10 standard for sizes 14- through 48-inch

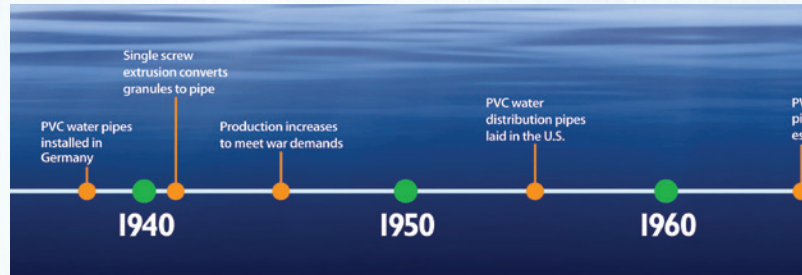
This eliminates the need for two separate PVC pipe standards, so AWWA C905 will no longer be published.

### MAJOR REVISIONS

Section IV of the standard’s Foreword lists the major revisions from the previous edition as follows:

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

- 1 *Pipe size range expanded to include nominal 54 and 60 in. (1,350 and 1,500 mm) along with all of the sizes covered in ANSI/AWWA C905. This expansion eliminates the need for a separate standard (i.e., ANSI/AWWA C905) for nominal sizes above 12 in. (300 mm).*
- 2 *Expansion of the scope to include nonpotable water applications.*
- 3 *The addition of a ring-tensile (apparent tensile strength at yield) test.*
- 4 *The addition of integrity verification test requirements for nonstandard pipe lengths.*



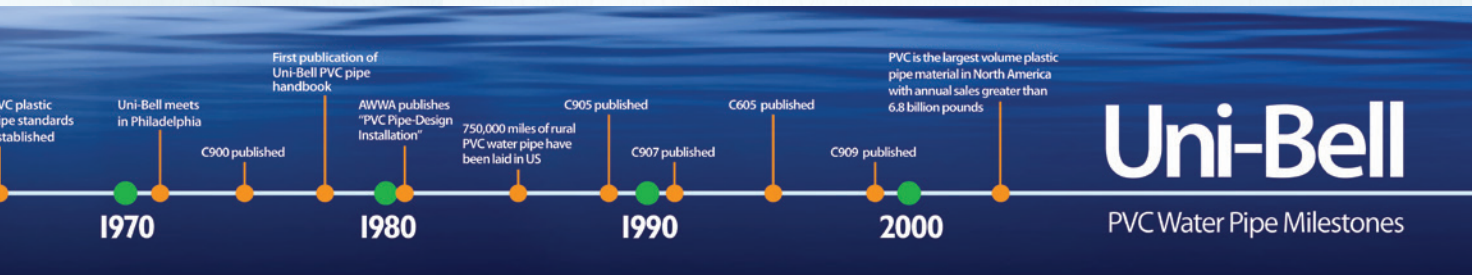
- 5 *The addition of qualification test requirements for fusion joints.*
- 6 *The addition of pressure classes 150, 200, and 250 psi for pipe with cast iron outside diameters (CIODs).*
- 7 *Removal of contract language from Sec. 5.4.*

One additional change not mentioned in the standard’s revision list was the inclusion of out-of-round requirements for pipe outside diameters.

Additional information on each of these major changes:

- 1 Expansion of size range: the size range for C900 was expanded to include 54- and 60-inch plus all of the sizes previously found in C905, rendering the C905 standard unnecessary. This was the culmination of a long process begun about 2003 in which the PVC Pipe and Fittings Committee began harmonizing C900 and C905 with the plan of combining the two into one standard.
- 2 Expansion of scope: inclusion of non-potable water applications was begun some years ago by AWWA and is being continued as each existing standard is revised.
- 3 Addition of ring-tensile test: this test can be used as an alternative for the burst-pressure test. This test was added due to safety concerns caused by the burst-pressure test’s combination of high pressures and large pipe sizes.
- 4 Addition of hydrostatic test requirements for non-standard lengths: some non-standard lengths do not fit into the equipment used for hydrostatic testing – these new requirements provide alternative testing methods.
- 5 Addition of qualification tests for fusion joints: joining of PVC pipe by fusion technology has become more common in recent years – these new qualification tests provide assurance that the fusion system will function as designed.
- 6 Addition of new pressure classes for CIOD pipe: these new products provide the engineer with additional choices to maximize design economy.





- 7 Removal of contract language: this is the result of a policy change at AWWA to remove contract language from all product standards when they are revised.

*Note: none of the revisions made in C900-16 affect the product design, materials requirements, or product performance of pipe and fittings manufactured to the previous standards C900-07 and C905-10. The most significant revision was the consolidation of the two standards into one.*

### AWWA MANUAL M23 – INCONSISTENCIES CLARIFIED

When a standard is revised, inconsistencies may arise between the standard and its associated manual. In this case, the manual is Manual M23 “PVC Pipe – Design and Installation,” 2002 edition. The C900-16 standard addresses this issue in Section II of the Foreword as follows:

*The pressure-class designation requirements and pressure design recommendations presented in this standard are different from those in AWWA Manual M23, PVC Pipe—Design and Installation, second edition (2002). The requirements of this standard take precedence over the design recommendations in AWWA Manual M23, second edition. Inconsistencies with AWWA M23 and this standard should be discussed with the manufacturer. The committee intends to revise the third edition of M23 to align with this standard.*

It is important to realize that this situation is typical in the AWWA system, where a standard always takes precedence over a manual.



### PIPE DESIGN

Also provided in Section II of the Foreword is a brief description of the pipe design process:

*Selection of Pressure Class. The minimum pressure class of the pipe selected should be equal to or greater than the system working pressure. The sum of the system working pressure and occasional surge pressure should not exceed 1.60 times the pressure class of the pipe. The system working pressure and recurring surge pressure should be analyzed using the method in Sec. 4.7. If surge pressures govern the selection of the pressure class, consideration should be given to removal of the cause of surge pressures or to the incorporation of surge suppressors in the system.*

A design example for cyclic surge pressures is presented in Section 6 of this Guide.

### OTHER PVC PIPELINE CONSIDERATIONS

This document discusses PVC pipes and PVC fittings covered by AWWA Standard C900-16. However, in addition to pipe and fittings, there are other items that must be considered during design of piping systems – for example:

- 1 Components such as pumps, valves, and hydrants can be affected by the engineer’s design decisions.
- 2 Surge pressures generated during normal operations and emergency situations are affected by pipe material and pipe wall thickness.
- 3 Thrust-restraint solutions are influenced by pipeline geometry and pressures.

Additional information on thrust-restraint design is found on the EBAA Iron website [www.ebaa.com](http://www.ebaa.com). Information on other items is found in Uni-Bell’s Handbook of PVC Pipe and in other documents found on the website [www.uni-bell.org](http://www.uni-bell.org).



# 2.0

## PVC PIPE

### MATERIALS

#### ► C900-16 Paragraph 4.2.2: Cell Class

Pressure pipe material must conform to cell class 12454 per ASTM D1784 “Standard Specification for Rigid Polyvinyl Chloride (PVC) Compounds and Chlorinated Polyvinyl Chloride (PVC) Compounds.” D1784 includes requirements for the material’s tensile strength, impact resistance, and modulus of elasticity.

#### ► C900-16 Paragraph 4.2.2: Hydrostatic Design Basis (HDB)

Pipe and fittings compounds must also qualify for a minimum HDB of 4,000 psi at 73.4°F in accordance with the requirements of:

- ASTM D2837 “Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products”
- PPI TR-2 “PVC Range Composition Listing of Qualified Ingredients”
- PPI TR-3 “Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials”

The HDB is the long-term hydrostatic strength of the PVC material. A safety factor of 2.0 is applied to this value to determine the allowable stress for hydrostatic design.

#### ► C900-16 Paragraph 4.2.4: Certification for Potable Water Service

Material intended for potable water use must be certified to the requirements of NSF Standard 61 “Drinking Water System Components – Health Effects.”



### PIPE PRODUCTS

#### ► New Products

The following new products were added to C900-16:

- All of the products previously found in AWWA C905
- Two new sizes for Cast Iron Outside Diameter (CIOD) pipe: 54- and 60-inch
- Two new CIOD dimension ratios (DRs): DR17 and DR27.5
- For the 4- through 12-inch CIOD sizes, three new Pressure Classes (PC):
  - 150 psi = DR27.5
  - 200 psi = DR21
  - 250 psi = DR17
- Additional PCs for existing CIOD sizes

#### ► Product Tables

On the following three pages are tables for the pipe products found in C900-16:

- 1 Table 1 – CIOD products listed by pipe size
- 2 Table 2 – CIOD products listed by pipe DR
- 3 Table 3 – IPS products listed by pipe size and DR

TABLE 1 : CAST IRON OUTSIDE DIAMETER (CIOD) PRODUCTS LISTED BY SIZE

Size (in)	DR	PC (psi)	Size (in)	DR	PC (psi)	Size (in)	DR	PC (psi)
4	27.5	150	16	41	100	30	51	80
	25	165		32.5	125		41	100
	21	200		27.5	150		32.5	125
	18	235		25	165		27.5	150
	17	250		21	200		25	165
	14	305		18	235		21	200
6	27.5	150	18	17	250	36	18	235
	25	165		14	305		17	250
	21	200		51	80		51	80
	18	235		41	100		41	100
	17	250		32.5	125		32.5	125
	14	305		27.5	150		27.5	150
8	27.5	150	20	25	165	42	25	165
	25	165		21	200		21	200
	21	200		18	235		18	235
	18	235		17	250		51	80
	17	250		14	305		41	100
	14	305		51	80		32.5	125
10	27.5	150	24	41	100	48	27.5	150
	25	165		32.5	125		25	165
	21	200		27.5	150		21	200
	18	235		25	165		51	80
	17	250		21	200		41	100
	14	305		18	235		32.5	125
12	27.5	150	24	17	250	54	27.5	150
	25	165		14	305		25	165
	21	200		51	80		51	80
	18	235		41	100		41	100
	17	250		32.5	125		32.5	125
	14	305		27.5	150		27.5	150
14	41	100	24	25	165	60	25	165
	32.5	125		21	200		51	80
	27.5	150		18	235		41	100
	25	165		17	250		32.5	125
	21	200		14	305		27.5	150
	18	235					25	165
	17	250						
	14	305						

**TABLE 2 : CAST IRON OUTSIDE DIAMETER (CIOD) PRODUCTS LISTED BY DIMENSION RATIO**

DR	PC (psi)	Size (in)	DR	PC (psi)	Size (in)	DR	PC (psi)	Size (in)
14	305	4	21	200	16	32.5	125	14
		6			18			16
		8			20			18
		10			24			20
		12			30			24
		14			36			30
		16			42			36
		18			4			42
		20			6			48
		24			8			54
17	250	4	25	165	10	41	100	60
		6			12			14
		8			14			16
		10			16			18
		12			18			20
		14			20			24
		16			24			30
		18			30			36
		20			36			42
		24			42			48
18	235	4	27.5	150	54	51	80	60
		6			60			18
		8			4			20
		10			6			24
		12			8			30
		14			10			36
		16			12			42
		18			14			48
		20			16			54
		24			18			60
21	200	4	21	200	30	32.5	125	
		6			36			
		8			42			
		10			48			
		12			54			
		14			60			



**TABLE 3 : IRON PIPE SIZE (IPS) PRODUCTS**

LISTED BY SIZE			LISTED BY DR			
Size (in)	DR	PC (psi)	DR	PC (psi)	Size (in)	
14	41	100	41	100	14	
	32.5	125			16	
	26	160			18	
	21	200			20	
16	41	100			24	
	32.5	125			30	
	26	160		36		
	21	200		32.5	125	14
18	41	100				16
	32.5	125				18
	26	160				20
	21	200				24
20	41	100	30			
	32.5	125	36			
	26	160	26		160	14
	21	200				16
24	41	100				18
	32.5	125				20
	26	160				24
	21	200		30		
30	41	100		36		
	32.5	125		21	200	14
	26	160				16
	21	200				18
36	41	100				20
	32.5	125				24
	26	160	30			
	21	200	36			

The new C900 standard has added 28 Iron Pipe Size (IPS) products that had been included in C905-10. Products range from 14- to 36-inch sizes in four DRs.

This set of IPS products found in C905 (and now in C900) has remained unchanged since the first C905 standard was published in 1988.

The current AWWA C900 product count stands at 137:

- CIOD pipe – 109 products
- IPS pipe – 28 products

## PIPE TESTING

### ► New Tests Added

Three tests were added to the standard in 2016:

- 1 Hydrostatic test for non-standard lengths
- 2 Ring-tensile test (an alternate for the burst test)
- 3 Fused-joint test

Each of these tests is discussed in this section.

### ► Discussion of Tests

In addition to dimensional testing requirements, the tests listed are included in C900-16. It is important to understand that the tests listed below are manufacturers' tests that should not be attempted in the field. For more information on the tests, the cited paragraphs should be reviewed:

- Sustained pressure (paragraphs 4.3.3.1 and 5.1.3) – also known as the 1000-hour test, this is a test that is “only for qualification of the compound and the extrusion process.” Semi-annual re-qualification testing is required for several sizes. For test pressures required for each DR, see Table 4.
- Burst pressure (paragraphs 4.3.3.2 and 5.1.4) – this test is run at a specified frequency per paragraph 5.1.4. For test pressures required for each DR, see Table 4.
- Hydrostatic pressure integrity (paragraph 4.3.3.3, 5.1.12, and 5.1.14) – this test is required for each piece of standard-length pipe. Non-standard lengths are tested once per day. Paragraph 5.1.14 permits testing at different test frequencies per agreement with the purchaser. For test pressures required for each DR, see Table 4.
- Flattening (paragraphs 4.3.3.4 and 5.1.6) – in this test, samples of pipe are flattened between two parallel plates until the pipe diameter has been reduced by 60% – there can be no evidence of splitting or cracking.
- Extrusion quality (paragraphs 4.3.3.5 and 5.1.7) – this test is also known as the “acetone-immersion test.”
- Ring tensile (paragraph 4.3.3.6) – this is also known as the “apparent tensile strength at yield.” This test can be used as an alternative to the burst-pressure test per the requirements of paragraph 5.1.4. The test stress for the ring-tensile test is the same as the hoop stress caused by the burst-pressure test.
- Fused-joint test (paragraph 4.6.2) – a coupon cut from a fused joint must provide 2:1 safety factor against joint separation at a stress equivalent to the burst-pressure stress.



**TABLE 4 : PRESSURES REQUIRED FOR TESTS**

Dimension Ratio	Pressure Class (psi)	Sustained-Pressure Test (psi)	Burst-Pressure Test (psi)	Hydrostatic Pressure Integrity Test
14	305	650	985	610
17	250	530	800	500
18	235	500	755	470
21	200	420	630	400
25	165	350	535	330
26	160	340	500	320
27.5	150	320	475	300
32.5	125	270	400	250
41	100	210	315	200
51	80	170	260	160



# 3.0

## PVC FITTINGS

### OVERVIEW

There are three types of PVC fittings found in AWWA standards:

- 1 PVC machined couplings in the C900-16 standard (as well as in previous editions of the C900 and C905 standards)
- 2 PVC fabricated fittings in the C900-16 standard (as well as in previous editions of the C900 and C905 standards)
- 3 PVC molded fittings in the C907 standard

The information in this document is a summary of the discussion and requirements found in AWWA C900-16. If additional information is needed, this standard and Uni-Bell's *Handbook of PVC Pipe* should be consulted.



### AWWA C900 – PVC MACHINED COUPLINGS

Machined couplings for use with AWWA C900 pipes are included in the C900-16 standard. These products were also included in the C900-07 and the C905-10 standards. There were no major revisions to the machined couplings sections found in the C900-07 and C905-10 standards.

#### ► C900-16 Section 4: Requirements

Subsection 4.4 “Machined Coupling Requirements” gives specifications for the following:

- Workmanship
- Dimensions
- Pressure tests
  - Burst pressure
  - Hydrostatic pressure
- Standard quantities

#### ► C900-16 Subsection 5.1: Quality Control and Qualification Test Requirements

Paragraphs in Subsection 5.1 give testing requirements for machined couplings as follows:

- 5.1.2 Coupling dimensions
- 5.1.5 Coupling burst strength
- 5.1.13 Coupling hydrostatic integrity test

### AWWA C900 – PVC FABRICATED FITTINGS

Fabricated fittings for use with AWWA C900 pipes are included in the C900-16 standard. Size range for fabricated fittings is the same as for pipe: 4- through 60-inch. There were no major revisions to the fabricated fittings sections found in the C900-07 and C905-10 standards.

#### ► C900-16 Section 3: Definitions

From Definition 4 on “Fabricated PVC Fittings,” fabricated fittings include:

- Single segments of thermoformed PVC pipe:
  - Bends
  - Couplings
- Multiple segments of PVC pipe cut into wedge shapes, or otherwise prepared to accept leg insertions, and joined under factory-controlled conditions to form an essentially homogeneous structure; the configurations of multiple segmented fittings are:
  - Tees – with an outstanding leg that is at 90° to the running leg, creating a “T” shape
  - Crosses – with two outstanding legs that are opposite each other and are at 90° to the running leg creating a “+” shape
  - Bends – to change direction; standard angles (11¼°, 22½°, 45°, and 90°) or custom-built bends at any angle
  - Couplings – to join two pipes with the same diameter



- Tapers – to gradually join two pipes with different diameters
- Reducers – to abruptly join two pipes with diameters that differ by more than 1 inch
- Adapters – to join two pipes with diameters that differ by 1 inch or less

▶ **C900-16 Section 4: Requirements**

Subsection 4.5 “Fabricated Fitting Requirements” gives specifications for the following:

- Workmanship
- Dimensions
- Segment joint quality
- Pressure test – two hours at two times the pressure class of the fitting

▶ **C900-16 Subsection 5.1: Quality Control and Qualification Test Requirements**

Paragraphs in Subsection 5.1 give testing requirements for fabricated fittings as follows:

- 5.1.8 Fitting segment fusion testing
- 5.1.9 Fitting segment solvent-cemented bond-quality testing
- 5.1.10 Fitting pressure tests





# 4.0

## ADDITIONAL CONSIDERATIONS

### CERTIFICATION FOR POTABLE WATER APPLICATIONS

#### ► C900-16 Paragraph 4.2.1: Regulatory Requirements

This section states that PVC pipe and fittings intended for potable water application must conform to the requirements of NSF Standard 61 “Drinking Water System Components – Health Effects” as well as the requirements of the Safe Drinking Water Act.

#### ► C900-16 Paragraph 4.2.4: Certification for Potable Water Service

This section requires that all PVC materials and products to be used for potable water shall be certified by an accredited testing agency for compliance with NSF Standard 61.

### PRODUCT CERTIFICATION

Many project specifications require that products be certified to meet applicable standards. For PVC pipe, there are several agencies that are qualified to certify products to AWWA C900 and other standards.

### MARKING REQUIREMENTS

#### ► C900-16 Paragraph 6.1.1: General

Pipe, machined couplings, and fabricated fittings must have identification markings that remain legible after normal handling, storage, and installation.

#### ► C900-16 Paragraph 6.1.2: Pipe

- Print-line requirements
  - Nominal size (in inches)
  - OD base (CIOD or IPS)
  - PVC
  - Dimension ratio
  - Pressure class (in psi)

- Hydrostatic integrity test pressure and/or frequency
- ANSI/AWWA C900-16
- Manufacturer’s name/trademark
- Manufacturer’s production date code or lot code
- Potable-water certifying agency’s mark (or alternatively, the words “NOT FOR POTABLE USE”)
- For joints that are deflectable axially, the maximum allowable axial joint deflection (in degrees)
- New requirement for deflectable joints
  - The requirement for printing the allowable axial deflection on the pipe is new in the 2016 edition.
  - This item was added to print-line requirements because of confusion caused by variations in allowable deflection for different pipe sizes and for different manufacturers. Identification of allowable deflection on each pipe ensures that installers will have the information necessary to prevent over-deflection in the field.
  - For a 20-foot length of pipe, each degree of angular deflection allows 4 inches of offset from a straight line.
- Print line information is required to repeat at intervals of not more than five feet.

### UPDATES TO PROJECT SPECIFICATIONS

The AWWA C905 standard has been superseded by the new C900-16. As a result, all project specifications referencing AWWA C905 for 14-inch and larger PVC pipe should be updated. The correct reference is now AWWA C900-16, since the standard includes all AWWA PVC pressure pipes from 4- through 60-inch sizes.



# 5.0

## PIPELINE DESIGN

### OVERVIEW

In addition to product data, the AWWA C900-16 standard includes engineering information needed for pipeline design. Topics included are:

- Safety factor
- Temperature considerations
- Long-term pressure capacity
- Short-term pressure capacity
- Cyclic pressure capacity

Each of these items is discussed below and a design example for cyclic pressure is presented.

### SAFETY FACTOR

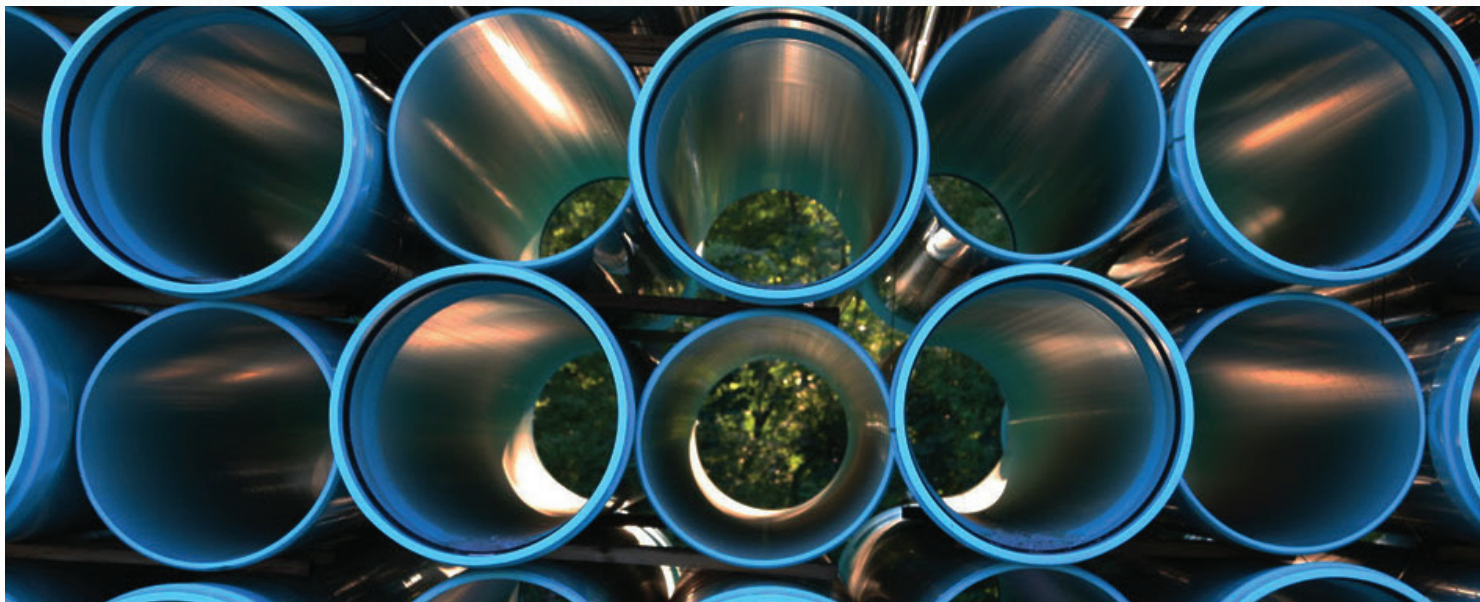
The safety factor is intended to cover variations in materials, manufacturing, handling, installation, and operations, as well as to be a cushion against unforeseen circumstances. The AWWA C900 standard uses a safety factor of 2.0 to calculate pressure capacities.

### TEMPERATURE CONSIDERATIONS

The mechanical properties of PVC materials are established at 73.4°F (23°C). Since PVC experiences a decrease in strength as the temperature rises, design pressure stresses must be adjusted per Table 5. It is important to realize that temperature de-rating is not intended for occasional temporary increases in temperature and is not a typical design consideration for most utilities.

TABLE 5 : TEMPERATURE COEFFICIENTS

Pipe Temperature		Pressure-Rating-Reduction Coefficient
°F	(°C)	
80	(27)	0.88
90	(32)	0.75
100	(38)	0.62
110	(43)	0.50
120	(49)	0.40
130	(54)	0.30
140	(60)	0.22





### LONG-TERM PRESSURE CAPACITY

The C900 standard defines the Pressure Class (PC) as “the design capacity to resist working pressure up to 73°F sustained operating temperature.” Thus, the PC is the PVC pipe’s long-term pressure capacity.

- Calculation: the PC is determined by dividing the long-term pressure strength by a 2.0 safety factor
- Example: for DR21 pipe, PC = 200 psi = long-term rating

### SHORT-TERM PRESSURE CAPACITY

PVC pipes are capable of accommodating short-term stresses far greater than the long-term stresses for which they are designed. The C900 standard recognizes this capability by including a short-term rating (STR) that is higher than the long-term rating. The standard defines Occasional Surge Pressure as “surge pressures caused by emergency operations, usually as the result of a malfunction (such as power failure, sudden valve closure, or system component failure).” These occasional surge pressures plus the pipe’s working pressure must not exceed the pipe’s STR, which is 1.6 x PC.

- Calculations – the STR is determined by dividing the burst pressure by a 2.0 safety factor. The same results are obtained by multiplying the PC by 1.6
- Example: for DR21 pipe, STR = 1.6 x PC = 320 psi = short-term pressure capacity

### CYCLIC PRESSURE CAPACITY

A design method is also provided for cyclic surge. The standard defines Recurring Surge Pressure as “surge pressures that occur frequently and are inherent to the design and operation of the system (such as normal pump startup or shutdown and normal valve opening or closure).” The standard’s design method requires calculation of the average stress and the stress amplitude generated by cyclic surges. From these two values, a cyclic life is determined from a chart of cyclic design curves found in an appendix.

- Calculation – the cyclic capacity is determined by dividing the pipe’s cyclic life by a 2.0 safety factor
- Example: a cyclic-surge design example in Figure 1

### CYCLIC PRESSURE DESIGN EXAMPLE

#### Definitions

- 1 Average stress – the hoop stress caused by static working pressure in the pipe
- 2 Stress amplitude – the increase in hoop stress caused by the cyclic surge pressure
- 3 Number of cycles provided by the pipe – this is the value determined in Figure 1

#### Design Method for Cyclic Pressures

- 1 Check operating temperature to determine if de-rating applies
- 2 Determine number of anticipated cycles for lifetime of project
- 3 Calculate maximum design pressure ( $P_{max}$ ) and minimum design pressure ( $P_{min}$ )
- 4 Calculate average stress ( $\sigma_{avg}$ ) and stress amplitude ( $\sigma_{amp}$ )
- 5 Determine number of cycles provided by the pipe (using Figure 1)
- 6 Compare cycles provided ( $C_{pro}$ ) to cycles required ( $C_{req}$ ); must be  $\geq SF = 2.0$
- 7 Calculate cyclic design life

#### Design Example – Parameters

- Project conditions (as determined by designer):
  - Pipe = Try AWWA C900 DR18 pipe
  - Working pressure (WP) = 160 psi
  - Recurring surge pressure ( $P_{rs}$ ) =  $\pm 30$  psi
- Design life = 100 years
- Number of cycles per day = 55
- Operating temperature ( $F_T$ ) = 60°F

#### Design Example – Calculations

- Temperature considerations:  $F_T = 60^\circ\text{F} < 73^\circ\text{F}$ , so temperature de-rating does not apply
- Cycles for 100-year life: (55 cycles/day)(365 days/yr) (100 yr) = 2,010,000 required ( $C_{req}$ )
- Calculate maximum pressure ( $P_{max}$ ) and minimum pressure ( $P_{min}$ ):
 
$$P_{max} = WP + P_{rs} = 190 \text{ psi}$$

$$P_{min} = WP - P_{rs} = 130 \text{ psi}$$



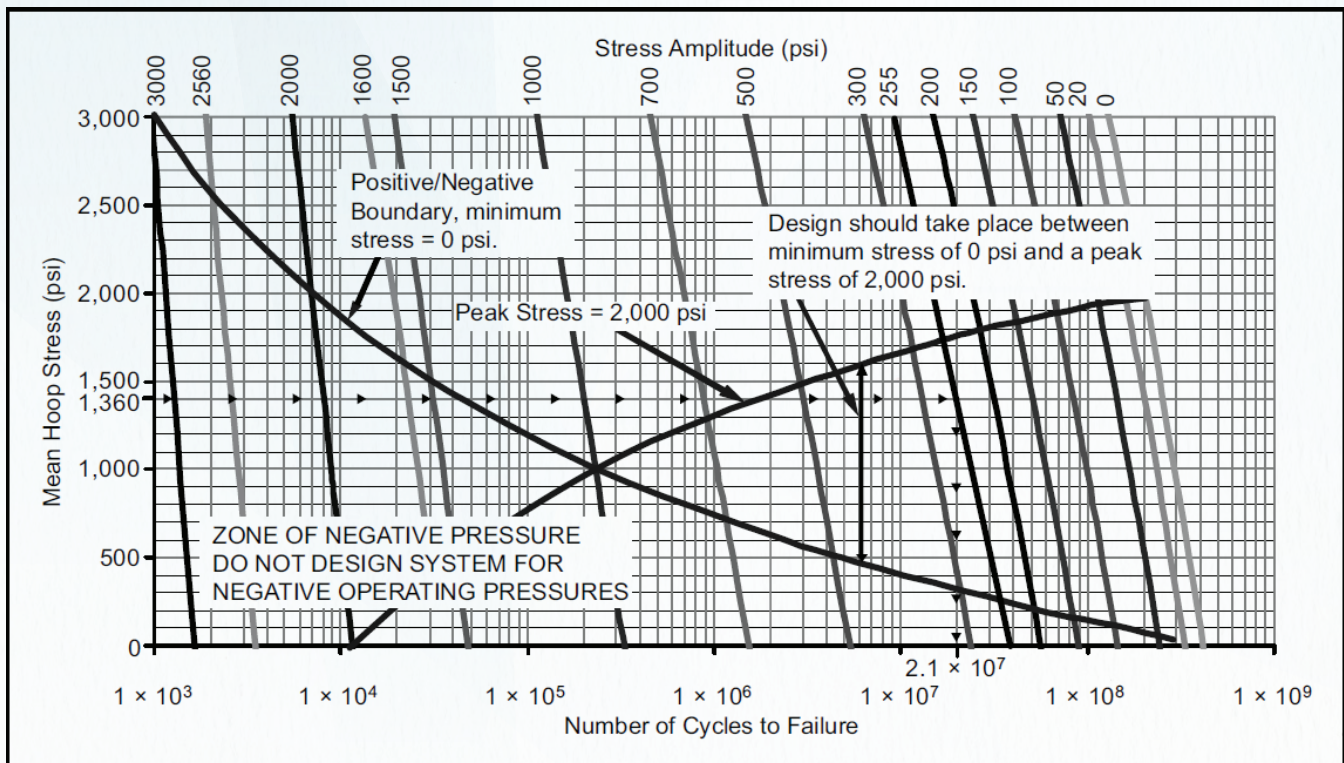
- Calculate average stress ( $\sigma_{avg}$ ) and stress amplitude ( $\sigma_{amp}$ ):

$$\sigma_{avg} = (P_{max} + P_{min})(DR-1)/4 = 1360 \text{ psi}$$

$$\sigma_{amp} = (P_{max} - P_{min})(DR-1)/4 = 255 \text{ psi}$$

- In Figure 1: Find the 1360 psi label on the y-axis. Follow the dotted line across until it intersects the 255 psi sloped line. Continue following the dotted line down to the x-axis and find the cyclic capacity = 21,000,000 cycles to failure = cycles provided ( $C_{pro}$ )

**FIGURE 1 : CYCLIC DESIGN CURVES**



Note: The current AWWA standard has an error in Appendix B, Figure B2:  $2.1 \times 10^4$  is incorrect;  $2.1 \times 10^7$  as shown in the figure above is accurate.

- Compare cycles provided to cycles required:  $21,700,000 \text{ provided} / 2,010,000 \text{ required} = 10.8 \gg \text{required SF} = 2.0$
- Calculate expected cyclic life:  $(21.7 \text{ million} / 2.0 \text{ million}) \times 100 \text{ yr} / 2.0 \text{ SF} = 540 \text{ yrs}$

#### Design Example – Results

- The trial pipe, AWWA C900 DR18, is suitable for the design conditions, providing enough cyclic capacity for more than 500 years, well beyond the 100-year design life
- DR21 pipe would also be sufficient for the design conditions, providing an expected cyclic life of  $(12.0 \text{ million} / 2.0 \text{ million}) \times 100 \text{ yr} / 2.0 \text{ SF} = 300 \text{ yrs}$



# 6.0

## SUMMARY

### COMBINING OF STANDARDS

The AWWA C900-16 standard is unusual because it combined two standards into one: C900-07 and C905-10 became C900-16. This means that the AWWA C905 standard has been rendered obsolete and will no longer be published.

### NEW PRODUCTS

The number of products in the previous standards C900-07 and C905-10 totaled 93 (15 in C900 and 78 in C905). C900-16 has a total of 137 products after the addition of 44 new items as follows:

- Two larger sizes of CIOD pipe
  - 54-inch in five DRs (5 products)
  - 60-inch in five DRs (5 products)
- Three new Pressure Classes for CIOD pipe
  - PC 150 psi in 4- through 60-inch sizes (16 products)
  - PC 200 psi in 4- through 12-inch sizes (5 products)
  - PC 250 psi in 4-through 30-inch sizes (11 products)
- Additional PCs for existing sizes
  - PC305 psi in 20- and 24-inch sizes (2 products)

The addition of 44 new products to the C900/C905 mix allows designers more flexibility to choose the most appropriate product for the application. It is important to realize that with this many items manufactured, not all products will be in stock at all times.

### NEW QUALITY TESTS

Three new tests were added:

- Ring-tensile test (apparent tensile strength at yield)
- Integrity verification test requirements for nonstandard pipe lengths
- Qualification test for fusion joints

### PROJECT SPECIFICATIONS – UPDATES NEEDED

The AWWA C905 standard has been superseded by the new C900-16. As a result, all project specifications referencing AWWA C905 for 14-inch and larger PVC pipe should be updated. The correct reference is now AWWA C900-16, since the standard includes all AWWA PVC pressure pipes from 4-through 60-inch sizes.

Whenever a new edition of a standard is published, there is a period of time necessary for phasing out the existing standard in favor of the new. For this new edition of C900, the phase-in is more complicated because of the addition of C905 sizes into C900-16. During the phase-in period, considerations include:

- Specifications – it may take several years for specifications to be revised to delete the AWWA C900-07 and C905-10 standards and replace with the new C900-16.
- Interim period – until these changes are made, the older specification requirements and older standards are still valid.
- Existing products – products made to the older standards are still acceptable for installation.







The publication notice for C900-16 was posted in the classified section of the AWWA Journal. Copies of the new standard may be ordered from the AWWA Bookstore. The Bookstore's contact information is:

**Web: [www.awwa.org/bookstore](http://www.awwa.org/bookstore)**

**Phone: 303.794.7711 or 800.926.7337**

**Fax: 303.347.0804**

**Address: 6666 West Quincy Avenue, Denver CO 80235**



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