

# **WATER AGENCIES' STANDARDS**

## **Design Guidelines and Standard Specifications for Potable Water, Recycled Water and Sewer Facilities**

### **SECTION 5**

#### **APPENDICIES**

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- A. Valve Testing Procedures
- B. New Product Submittal Form
- C. Revisions
- D. Wet-Tapping Guidelines
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## **WATER AGENCIES' STANDARDS**

### **APPENDIX A BUTTERFLY AND RESILIENT WEDGE GATE VALVE TESTING PROCEDURE**

#### **PART 1 GENERAL**

##### **1.01 PURPOSE**

This section describes requirements and procedures for the mil thickness testing, holiday testing and hydrotesting of butterfly valves (BFV) and the hydrotesting of resilient wedge gate valves (RWGV).

##### **1.02 REFERENCE STANDARDS**

The publications listed below form part of this appendix to the extent referenced and are referred to in the text by basic designation only. References shall be made to the latest edition of said standards unless otherwise indicated.

AWWA C210	-	Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C504	-	Rubber-Seated Butterfly Valves
AWWA C509	-	Resilient-Seated Gate Valves for Water Supply Service
AWWA C515	-	Reduced-Wall Resilient-Seated Gate Valves for Water Supply Service
AWWA C550	-	Protective Epoxy Coatings for Valves and Hydrants
NACE RPO188	-	Discontinuity (Holiday) Testing of Protective Coatings
SSPC	-	Steel Structures Painting Council

##### **1.03 RELATED WORK SPECIFIED ELSEWHERE**

WAS Standard Specifications 15000, 15100 and 15102.

##### **1.04 MANUFACTURER FACTORY TESTING REQUIREMENTS**

- A. The manufacturer shall test each BFV in accordance with AWWA C504 and each RWGV in accordance with AWWA C509 or AWWA C515, and this Appendix, prior to shipping the valve.
- B. Each BFV and RWGV shall be hydrotested by the manufacturer after the interior and exterior coatings have been applied and cured.
- C. Each BFV shall be hydrotested by the manufacturer after the actuator has been mounted and adjusted.
- D. Each BFV and RWGV shall be dry film thickness tested and holiday detection tested by the manufacturer prior to the valve being shipped.
- E. Each BFV and RWGV shall be operated from the fully closed to fully open to fully closed positions prior to the completed valve being shipped.

- F. Prior to shipment, the manufacturer shall provide notarized certification that each BFV and RWGV supplied has successfully completed the tests required by AWWA, ANSI, ASTM and this Appendix.
- G. Each valve shall be shipped with end seals and shall be wrapped in shipping plastic.

#### **1.05 TESTING REQUIREMENTS PRIOR TO INSTALLATION**

- A. Valve testing shall be provided by either the supplier or the contractor at no cost to the District. Valves failing to pass the testing regimen specified by this Appendix shall be either replaced or repaired at no cost to the District. Replaced or repaired valves shall be tested as specified in this Appendix.
- B. Testing of valves shall not be scheduled until a submittal has been processed and approved by the District.
- C. Valves shall be tested within a 50-mile radius of the District office.
- D. Valves shall be tested in the presence of a District Representative. It is the responsibility of either the supplier or the contractor to schedule the witnessing of the testing with the District Representative assigned to the project. Requests for valve testing shall be made to the District a minimum of five (5) working days in advance of the desired testing date.
- E. All BFV's shall be mil thickness tested, holiday detection tested and hydrotested by either the supplier or the contractor prior to installation in the field. Generally, the valves will be tested at the supplier's facility prior to shipment to the field.
- F. A representative sample of RWGV's on a project may be selected for testing by the District Engineer. The District Engineer shall indicate on the approved submittal when RWGV's have been selected for testing.
- G. The procedures and requirements for the testing of valves shall be as described in Part 3 of this Appendix. Butterfly valves shall be required to pass all the tests described in Part 3 of this Appendix prior to being incorporated into the project. When selected for testing, RWGV's shall be required to pass the hydrotesting phase in accordance with Part 3 of this Appendix.
- H. Valves not passing the tests required shall be replaced or repaired at the discretion of the District Engineer. Replaced valves shall be in accordance with this Appendix. Repaired valves shall repeat the phase of the required testing previously failed in addition to the phases not yet completed. Repaired valves may be rejected and required to be replaced if they repeatedly fail any phase of the testing.

#### **1.06 SUBMITTALS**

- A. Submittals for BFV's and RWGV's are to be made in accordance with the requirements of Section 15000, 15102 and 15108. Submittals for District-funded capital improvement projects (CIP) should be directed to the Project Manager (PM) of the project. Submittals for developer-funded projects should be directed to the Q/C Division or the District Representative for that particular project.
- B. Submittals for District-funded CIP's shall be reviewed and approved by the Project Manager or the designee, and provided to the Q/C Division.

- C. Submittals for developer-funded projects shall be reviewed and approved by the District Representative.

## **PART 2 MATERIALS**

### **2.01 TESTING MEDIA**

The testing media for hydrostatic testing shall be an approved source of potable water. Testing with a gaseous media is prohibited.

### **2.02 TESTING EQUIPMENT FURNISHED BY THE SUPPLIER OR CONTRACTOR**

The supplier or the contractor shall furnish all necessary personnel and hydrotesting equipment, including test pump, hoses, gages, blind flanges and a safe means of turning the valves over. Insufficient personnel or substandard or unsafe equipment shall be grounds for the District Representative to cancel the testing until adequate personnel and acceptable equipment have been provided.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

The following paragraphs provide clarification of specific tasks and procedures involved in the testing of valves.

- A. Testing of valves shall be in the following order:

1. Pre-Testing Inspection
2. Hydrostatic Test
3. Dry Film Thickness Test
4. Holiday Detection Test

### **3.02 PRE-TESTING INSPECTION**

- A. On the date and time agreed the District Representative shall travel to the testing site. The testing site must be within a 50-mile radius of the District Office.
- B. The District Representative responsible for the project will receive one copy of the approved valve submittal. The District Representative shall take the submittal to the testing site to verify the valves to be tested correspond to those on the approved submittal.
- C. Upon arrival at the testing site, the District Representative shall assess the readiness of the tester's personnel and equipment to perform the testing. If there is not sufficient personnel and equipment present to perform the tests in a timely manner, the District Representative will cancel the testing scheduled for that day. The District Representative

will inform the tester of the reason(s) for canceling the test and instruct the tester to reschedule the testing.

- D. When the testing is being performed in conjunction with a CIP Project, the District Representative shall notify the PM when either testing has been cancelled or there are testing failures. The PM may back charge the Contractor for the time the District Representative has spent.
- E. District Representative will visually inspect each valve (class and configuration), operation of valve, and actuator for compliance with the submittal. Valves not in compliance with the approved submittal shall be rejected.
- F. District Representative will visually inspect each valve for obvious damage or substandard construction. Valves found to be damaged or of substandard construction shall be rejected.
- G. District Representative will record the model and serial number of each valve and its actuator on the Valve Test Sheet (Exhibit A).

### **3.03 HYDROSTATIC TESTING PROCEDURES**

- A. Each valve shall be tested on both sides at its rated pressure. During the hydrostatic test, there shall be no leakage through the valve body, end joints, or shaft seals, nor shall any part of the valve be permanently deformed.
- B. The testing medium shall be water. Under no circumstances is a gas to be used as the test medium.
- C. The test duration on each side of the valve is 15 minutes. The test equipment will be disconnected during this time.
- D. Valves require careful handling when turning them over. The District Representative shall stop the testing activity if the manner used by the tester to handle the valves is unsafe or will result in damage to the valve. The flange faces are especially susceptible to damage if the valve is not properly handled.
- E. Valves exhibiting no visible leakage, no decrease in the initial test pressure or no deformation shall be considered passed.
- F. Valves exhibiting visible leakage, a decrease in the initial test pressure, or deformation shall be considered rejected. Valves which fail the hydrostatic test shall be repaired or replaced at the District's discretion.
- G. Only personnel authorized by the valve manufacturer shall repair valves when repairs are permitted by the District Engineer. Unless the valve manufacturer has provided authorization, supplier or contractor personnel shall not perform repairs.
- H. Indicate the results of the hydrostatic test on the Valve Test Sheet (Exhibit A).

### **3.04 DRY FILM THICKNESS TESTING PROCEDURE**

- A. The dry film thickness gage shall be calibrated prior to beginning the taking of the mil readings and periodically during the testing. Use plastic shims or standardized plates and follow the instructions provided with the instrument.

- B. A minimum of four readings should be taken on each side of the disc and a minimum of three readings should be taken on each side of the interior of the valve body. Additional readings should be taken near edges and around intricate assemblies and where the coating is likely to be thin.
- C. Mark the spot and mil reading at each location where the reading were taken with a felt tip pen. More readings may be taken at the discretion of the District Representative.
- D. The minimum dry film thickness of any reading shall be a minimum 8 mils. Mark with felt pen any location where the coating thickness is less than minimum dry film thickness required.
- E. Valves with adequate coating thickness shall be considered passed and the results shall be indicated on the Valve Test Sheet (Exhibit A).
- F. Valves with inadequate coating thickness in any location shall be rejected. Qualified personnel approved by the valve manufacturer shall repair valves with unacceptable coating thickness at a qualified facility in accordance with the valve manufacturer's recommendations.

### **3.05 HOLIDAY DETECTION TESTING PROCEDURE**

- A. The interior surface of each valve shall be tested in accordance with the most current revisions of NACE Standard RPO188, except as modified below.
- B. Assure the instruments to be used are properly calibrated, with batteries charged, and in proper working order prior to use.
- C. High-Voltage Holiday Detector set-up:
  1. Select output voltage (on the detector) to the desired setting. Use 100 volts per mil thickness. The 8-mil thickness specified requires a setting of 800 volts.
  2. Connect the ground wire to the valve to be tested. Assure a sound metallic contact is achieved. Plug the ground wire into the detector.
  3. Select the appropriate powerpack, wand length, and electrode (stainless brush or rubber paddle) to be used. Assemble the powerpack, wand electrode and plug the assembly into the high voltage port on the detector.
  4. Turn the detector switch on. An audible tone will be heard if the instrument is ready to use. Verify the working of the instrument by running wand across the ground bare metallic surface of the valve. A buzz tone will be heard.
- D. The surface to detected should be dry. A wet surface will "carry over" a holiday in an area.
- E. Cover all surface area with the electrode in a slow thorough motion, testing all interior coated surfaces. Most holidays are found on or around casting numbers, nuts, bolts, and sharp edges. When a holiday is detected, circle area with a black permanent felt pen.
- F. Valves with no holidays in the coating shall be considered passed and the results indicated on the Valve Testing Sheet (Exhibit A). Proceed to the Hydrotesting phase of the testing.

- G. Valves with holiday(s) in the coating in any location shall be rejected. Qualified personnel approved by the valve manufacturer shall repair valves with unacceptable coating at a qualified facility in accordance with the valve manufacturer's recommendations. Indicate on the Valve Test Sheet (Exhibit A) that the valve failed this portion of the test.

### **3.06 REPORTING AND MARKING**

- A. The District Representative shall record the results of each phase of the testing of each valve on the Valve Test Sheet (Exhibit A).
- B. The District Representative shall mark the flange of each side of the valve to indicate the results of the test. The required marking convention is shown in Exhibit B.
  - 1. Marking shall be made using a white metal marker.
  - 2. The markings should be made on the portion of the valve flange that will be readily visible in the field. For valves to be used in buried service, the markings should be oriented toward the top of the trench.
- C. The District Representative shall visually check each valve in the field for proper markings prior to installation. Any valve not displaying the proper markings shall be immediately rejected and the contractor shall be instructed to remove it from the site.

END OF SECTION

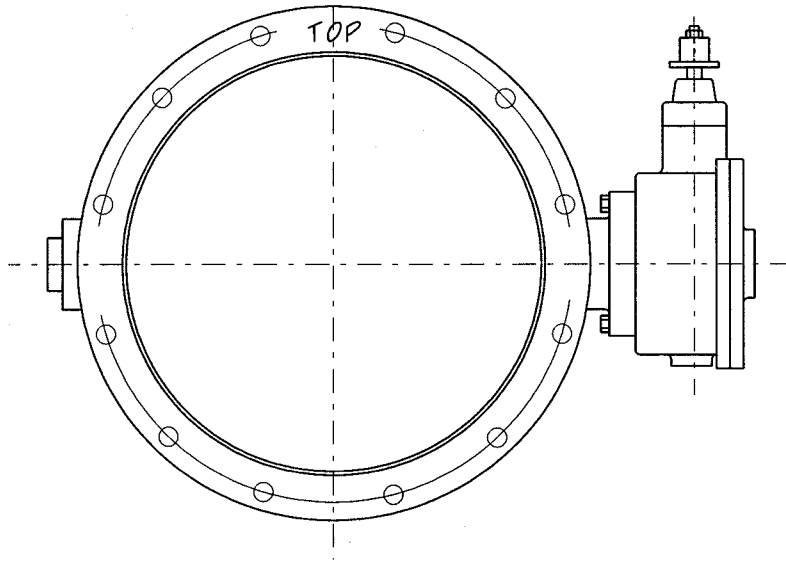
**EXHIBIT A  
VALVE TEST SHEET**

**WO**

**PROJECT:**

NO	DATE	SIZE	MGFR	SERIAL	TYPE	ACTUATOR	TEST RESULTS			COMMENT
							MILS	HOLIDAY	HYDRO	
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
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22										
23										
24										

PLACE MARKINGS HERE



W0 2365 7/10/00 ↑ OK RTK

W0 2365 7/10/00 ↓ OK RTK

PASSING MARKINGS

W0 2365 7/10/00 ↑ NG RTK

FAILING MARKINGS

VALVE TEST MARKING

WATER AGENCIES STANDARDS

COMMITTEE APPROVAL: 03/01/2001

DRAWING NUMBER: EXHIBIT B



## **APPENDIX "B" APPROVED MATERIALS**

To: Manufacturers and Suppliers of Water, Recycled Water and Sewer Products

Subject: Approved Materials Product Submittal Package

Materials used by contractors to construct water, recycled water and sewer systems shall conform to the Water Agencies' Standard Specifications. Products to be used in the construction of water, recycled water and sewer systems are listed in the Approved Materials List contained within the Standard Specifications.

If your product is not currently included in the Approved Materials List and you would like it to be considered for inclusion, please complete the attached submittal form and return it to one of the persons listed on the submittal form.

### PRODUCT/PROCEDURE ACCEPTANCE FLOWCHART

The attached flowchart illustrates the process that is generally followed in considering revisions or new materials for inclusion on the Approved Materials List.

### NEW PRODUCT SUBMITTAL FORM

The purpose of the submittal form is to provide adequate information to determine if a product meets WASC criteria.

Complete and thorough information expedites the evaluation of a product. Conversely, extraneous information may delay the evaluation process. Therefore, please fill out the form completely and compile sufficient product technical information to evaluate the product, but not so much that one must "wade" through it. The review process typically requires eight (8) weeks from the submittal date to complete.

Product representatives may be asked to make a presentation regarding the proposed product. Presentations shall be made only at the request of the WASC.

A written response will be provided to the submitter when the WASC Approved Materials Subcommittee has rendered a decision on the proposed product.

### PRODUCT EVALUATION

Product samples may be required for evaluation by each agency. Product evaluation may take up to six (6) months to perform. Product samples shall be provided only at the request of the WASC.

Thank you for giving us the opportunity to review your product.

Sincerely,

Water Agencies' Standards Committee  
Materials Subcommittee



## NEW PRODUCT SUBMITTAL FORM

This form provides information required to determine if a proposed product is suitable for inclusion on the WAS Approved Materials List.

Please fill out the form completely and attach any additional pertinent information or materials. Incomplete forms will not be considered.

No obligations on the part of the Water Agencies' Standards Committee are either inferred or implied by receipt of this form.

Use a separate form for each product to be considered. Separate forms are not required for various sizes of the same product, as long as the products components are the same, varying only in the size of components.

Submit the completed form and product information to one of the following Water Agencies' Standards Committee representatives:

**Tim Ross**

Helix Water District  
1233 Vernon Way  
El Cajon, CA 92020

**Brett Sanders**

Lakeside Water District  
10375 Vine Street  
Lakeside, CA 92040

**Mike Plasterer**

Otay Water District  
2554 Sweetwater Springs Boulevard  
Spring Valley, CA 91978-2004

**Ken Gallo**

Padre Dam Municipal Water District  
P. O. Box 719003  
Santee, CA 92072-9003

**Wes Stalker**

Ramona Municipal Water District  
105 Earlham Street  
Ramona, CA 92065-1599

**Victor Graves**

San Dieguito Water District  
505 S. Vulcan Avenue  
Encinitas, CA 92024

**Dana Johnson**

Santa Fe Irrigation District  
P. O. Box 409  
Rancho Santa Fe, CA 92067-0409

Submittal Date \_\_\_\_\_

Product Name and Model \_\_\_\_\_

Generic Description of Product \_\_\_\_\_

Available Sizes \_\_\_\_\_

Submitted by: Company Name \_\_\_\_\_

Street Address \_\_\_\_\_

City, State and Zip \_\_\_\_\_

Contact Person \_\_\_\_\_

Phone Number \_\_\_\_\_ FAX Number \_\_\_\_\_

Email Address \_\_\_\_\_

**MANUFACTURER INFORMATION**

Manufacturer: \_\_\_\_\_

Headquarters Address: \_\_\_\_\_

City, State and Zip: \_\_\_\_\_

Headquarters Phone # \_\_\_\_\_ Headquarters FAX # \_\_\_\_\_

Local Office Address: \_\_\_\_\_

City/State/Zip: \_\_\_\_\_

Local Phone # \_\_\_\_\_ Local FAX # \_\_\_\_\_

How long has the manufacturer been producing related products?

List related products:

List other trade names used by manufacturer:

Specifically where is the product produced? \_\_\_\_\_

**PRODUCT INFORMATION**

What is/are the appropriate ANSI, UL, ASTM, or NSF standard(s)?

Does the product meet it/them? If not, please explain:

What is/are the appropriate AWWA standard(s)?

Does the product meet it/them? If not, please explain:

What is/are the appropriate Water Agencies' Standard(s)?

Does the product meet it/them? If not, please explain:

What laboratories, if any, have tested and approved the product?

How long has the product been on the market?

List the most commonly-used competitors to the product:

Manufacturer	Product
_____	_____
_____	_____
_____	_____
_____	_____

What are the operational advantages and disadvantages of the product compared to similar products shown on the Approved Materials List?

Advantages:

Disadvantages:

What are the financial advantages and disadvantages of using the proposed product compared to similar products shown on the Approved Materials List? Provide a current price list for the product.

Advantages:

Disadvantages:

What other agencies in the Western United States are using the product?

Agency	How Long?	Contact Person	Phone
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

List the local suppliers that stock the product:

Supplier	City
_____	_____
_____	_____
_____	_____
_____	_____

What is the typical availability and delivery lead time for the product?

List the length of the product warranty and what the warranty covers. Attach a copy of the warranty.

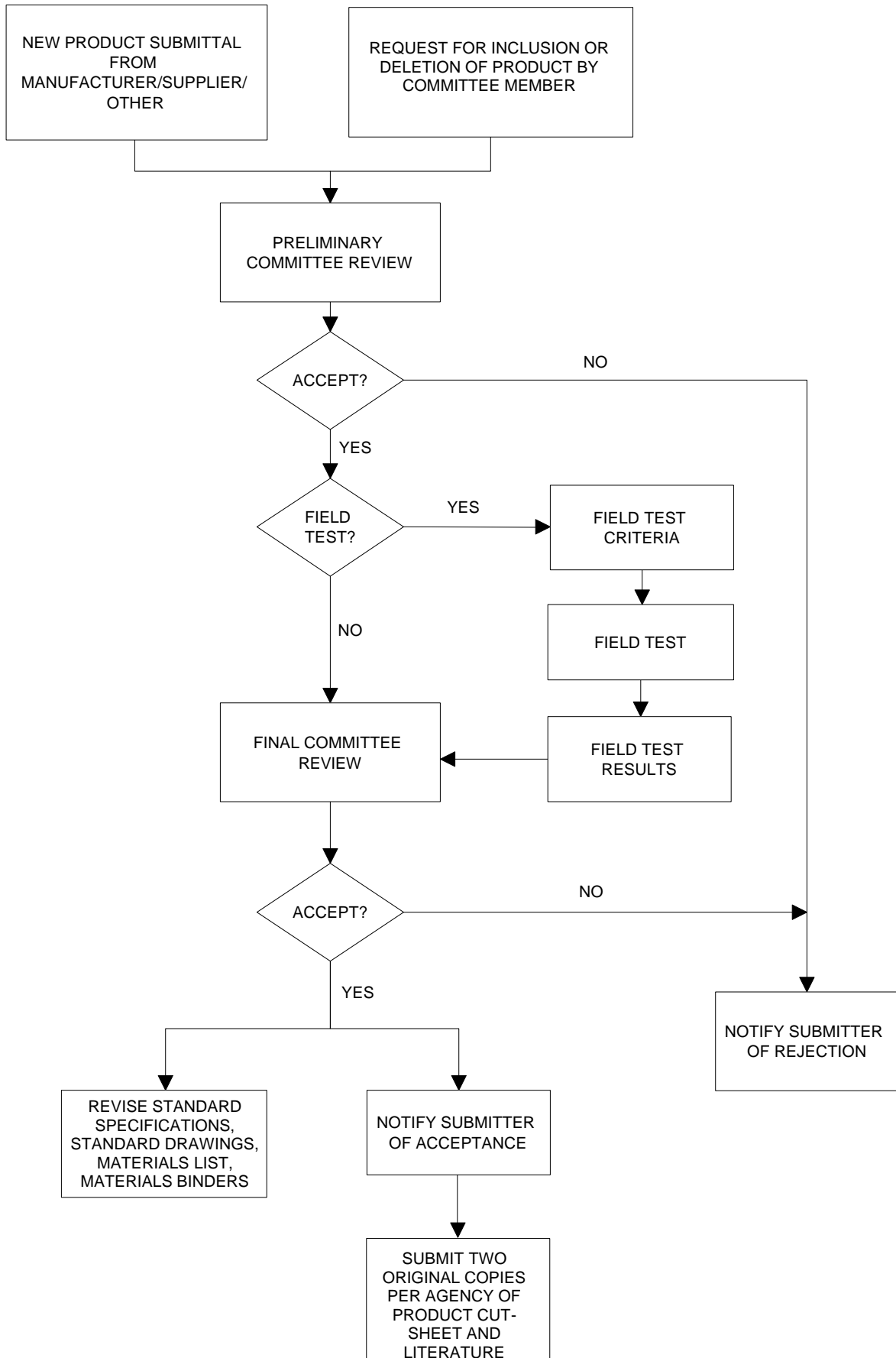
**TECHNICAL INFORMATION**

Please attach relevant technical information about the product. The information must include specific details about all standard and optional features available. The optional features being provided to the Water Agencies' Standards Committee must be indicated by underlining or highlighting. Provide Material Safety Data Sheets (MSDS) and National Sanitation Foundation (NSF) certification information, if applicable, for products submitted.

**ADDITIONAL COMMENTS** (use additional sheets if necessary)

# WATER AGENCIES' STANDARDS PRODUCT SUBMITTAL PROCEDURE

Revised: 11-01-2002





## APPENDIX "C" REVISIONS

February 1, 2008

The *Water Agencies' Standards Committee (WASC)* has adopted these *Water Agencies' Standard Specifications* in an effort to simplify and standardize the construction of facilities for those who provide materials and design or construct projects in the geographical areas administered by the WASC member agencies. The five original agencies signatory to this effort are Helix Water District, Otay Water District, Padre Dam Municipal Water District, Lakeside Water District, and Riverview Water District.

It is the intent of the *WASC* that the *Standard Specifications* be dynamic documents, and annual revisions are planned. Interim revisions will be issued if the need arises. The *WASC* will meet quarterly to consider written comments submitted by interested parties.

The *WASC* will continuously accept proposed corrections, revisions or additions for review. Interested parties are requested to use the blank submittal form attached to submit comments or proposed changes to the Standard Specifications or Standard Drawings. Refer to Appendix "B" herein for information regarding proposed modifications to the Approved Materials List. Comments or proposed changes to the Standard Specifications or Standard Drawings may be directed to any one of the persons listed below:

### **Helix Water District**

Scott Hamren  
7811 University Avenue  
La Mesa, CA 91941-4927

### **Lakeside Water District**

Brett Sanders  
10375 Vine Street  
Lakeside, CA 92040

### **Otay Water District**

Doug Marple  
2554 Sweetwater Springs Boulevard  
Spring Valley, CA 91978-2096

### **Padre Dam Municipal Water District**

Ken Gallo  
P. O. Box 719003  
Santee, CA 92072-9003

### **Ramona Municipal Water District**

Tim Stanton  
105 Earlham Street  
Ramona, CA 92065-1599

### **San Dieguito Water District**

Victor Graves  
505 S. Vulcan Avenue  
Encinitas, CA 92024

### **Santa Fe Irrigation District**

Dana Johnson  
P. O. Box 409  
Rancho Santa Fe, CA 92067-0409

Proposed changes will be reviewed by the *WASC*, and will be approved, approved with revisions, rejected, or referred to a subcommittee for further review. The individual or organization that submitted the proposed change will be notified of the outcome of the *WASC* review. Changes adopted by the *WASC* will be incorporated into periodic updates.

It is intended that these *Water Agencies' Standards* be printed and distributed periodically, incorporating all changes approved by the *WASC* since the last printing. The printing and distribution will take place when the *WASC* determines that revisions are sufficient in number or nature to warrant issuance of an updated package.

13-JAN-2005 10:34

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REVISION FOR WATER AGENCIES' STANDARDS

- Design Guidelines                       Standard Specifications                       Standard Drawings
- Approved Materials List                       Appendices                      DATE: \_\_\_\_\_

SUBMITTED BY: NAME: \_\_\_\_\_ PHONE NO. \_\_\_\_\_  
 AGENCY: \_\_\_\_\_ E-MAIL: \_\_\_\_\_  
 ADDRESS: \_\_\_\_\_

WAS SUBCOMMITTEE ACTION  
 DATE: \_\_\_\_\_  
 RECOMMENDED  AS MODIFIED  REJECTED

WAS COMMITTEE ACTION  
 DATE: \_\_\_\_\_  
 RECOMMENDED  AS MODIFIED  REJECTED

**WATER AGENCIES' STANDARDS  
 PROPOSED REVISIONS**

DATE RECEIVED: \_\_\_\_\_  
 SUBMITTAL NUMBER: \_\_\_\_\_

## **WATER AGENCIES' STANDARDS**

### **STANDARD SPECIFICATIONS**

#### **APPENDIX D WET-TAPPING GUIDELINES**

##### **PART 1 GENERAL**

###### **1.01 DESCRIPTION**

This section establishes guidelines for wet-tapping operations on existing water mains. These guidelines shall be used in conjunction with Section 15000 of the Water Agencies' Standards (WAS).

###### **1.02 RELATED WORK SPECIFIED ELSEWHERE**

WAS Standard Drawings.  
WAS Standard Specifications 15000, 15041, and 15044.

###### **1.03 PIPE TAPPING (WET TAPPING)**

All pipe tap (wet tap) connections to existing pipelines, whether for mainline extension or service laterals, shall be performed by the District. In some cases, the contractor may perform wet taps with prior approval of the District Engineer and in accordance with Section 15000 and these guidelines.

##### **PART 2 MATERIALS**

###### **2.01 TAPPING EQUIPMENT**

The Contractor shall provide materials as called for in Section 15000 and as described below.

- A. The tapping machine shall have the ability to positively flush all shavings and other residue created when installing tapped outlets of 100mm (4") or larger.
- B. The shell cutter bell on the tapping machine shall be tapped with a 50 mm (2") minimum outlet.
- C. A ball valve shall be installed on the outlet to regulate flow.
- D. A hose and filter shall be connected to the ball valve to retrieve shavings and residue generated during the tapping process.
- E. A multi-toothed shell cutter is required to minimize the size of shavings generated when tapping PVC pipe. The shell cutter pilot tool shall be designed to capture the coupon generated by performing the wet tap.

- F. The tapping machine shall be filled with water prior to commencing the tapping procedure.

## **PART 3 EXECUTION**

### **3.01 GENERAL**

The Contractor shall provide labor and equipment necessary to perform the wet tap as called for in Section 15000 and as described below.

- A. District personnel shall perform all wet taps unless otherwise indicated on the Approved Plans or otherwise directed by the District Engineer. Wet taps not performed by District personnel shall be continuously witnessed and approved by the District Engineer.

### **3.02 TAPPING PROCEDURES**

Wet-tapping operations shall be performed in accordance with Section 15000 and the following:

- A. The tapping machine shall be cleaned and disinfected prior to attachment to the tapping valve and saddle.
- B. Feed settings and motor speed of the tapping machine shall be constantly monitored to insure proper operation.

### **3.03 DEWATERING PROCEDURES**

Collection and disposal of water generated by performing the wet tap shall comply with all Regional Water Quality Control Board requirements.

END OF SECTION

# WATER AGENCIES' STANDARDS

## Design Guidelines for Water and Sewer Facilities

### APPENDIX E UNITS OF MEASURE

#### 1. PURPOSE

The purpose of this section is to provide parameters and their abbreviations for units of measure used in the WAS Design Guidelines.

#### 2. UNITS OF MEASUREMENT

Units of measurement to be used in design calculations shall conform to the United States system of measurement unless industry practice is to use metric units. Commonly used units and their abbreviations are listed in Table E-1.

**Table E-1  
Units of Measure**

<b>Parameter</b>	<b>Abbreviation</b>
Flow/Discharges	
(United States) million gallons per day	mgd
(United States) gallons per minute	gpm
(United States) gallons per hour	gph (for chemicals only)
(United States) gallons per day	gpd
cubic feet per second	cfs
cubic feet per minute	cfm
pounds per day	lb/day
pounds per hour	lb/hr
standard cubic feet per minute	scfm (for gases only)
liters per second	lps
Volume	
(United States) gallons	gal
cubic inches	cu in
cubic feet	cu ft
cubic yards	cy yd
acre-feet	ac-ft
liter	l
milliliter	ml
cubic meters	m <sup>3</sup>
Weight or Force	
ounce	oz
pounds	lb
ton	ton
kilogram	kg
gram	g
milligram	mg
thousand pounds	kip

**Table E-1**  
**Units of Measure**  
*continued*

Parameter	Abbreviation
<b>Length</b>	
inches	in
feet/foot	ft
yards	yd
millimeter	mm
meter	m
micron	$\mu$
<b>Area</b>	
acres	ac
square yard	sq yd
square feet	sq ft
square inches	sq in
<b>Velocity</b>	
feet per second	fps
feet per minute	fpm
miles per hour	mph
revolutions per minute	rpm
<b>Pressure</b>	
feet of water	ft water
pounds per square inches	psi
pounds per square inches absolute	psia
pounds per square inches gage	psig
<b>Power</b>	
Kilowatts	kW
Horsepower	hp
Volts ac	Vac
Volts dc	Vdc
amperes	A
milliampere	mA
power factor	pf
frequency	Hz
<b>Temperature/heat</b>	
degrees Centigrade (Celsius)	$^{\circ}\text{C}$
degrees Fahrenheit	$^{\circ}\text{F}$
British Thermal Unit	Btu
<b>Density</b>	
pounds per cubic feet	pcf
pounds per gallon	lb/gal
kilograms per cubic meter	$\text{kg}/\text{m}^3$

**Table E-1**  
**Units of Measure**  
*continued*

<b>Parameter</b>	<b>Abbreviation</b>
<b>Concentration</b>	
milligrams per liter	mg/l
parts per billion	ppb
parts per million	ppm
pounds per million gallons	lb/10 <sup>6</sup> gal
pounds per gallon	lb/gal
pounds per cubic feet	pcf
<b>Loadings</b>	
pounds per square inch	psi
pounds per square feet	psf
gallons per day per square foot	gpd/sf
gallons per day per linear foot	gpd/ft
gallons per minutes per square foot	gpm/sf

### 3. CONVERSION FACTORS

Commonly used USCS to USCS unit conversion factors are listed in Table E-2. Commonly used USCS to metric conversion factors are listed in Table E-3. A simple unit conversion program can be downloaded free of charge with program registration at the following website:

<http://www.joshmadison.com/software/convert/>

**Table E-2**  
**Typical Water Industry USCS Conversion Factors**

<b>Area</b>	
1 square inch = 0.006944 square foot	1 square foot = 144 square inches
1 square foot = 0.1111 square yard	1 square yard = 9 square feet
1 acre = 43,560 square feet	1 square foot = 2.2956x10 <sup>-5</sup> acre-foot
<b>Flowrate</b>	
1 cubic foot/second = 448.83 gallons/minute	1 gallon/minute = 0.002228 cubic foot/second
1 cubic foot/second = 646,300 gallons/day	1 gallon/day = 1.547x10 <sup>-6</sup> cubic foot/second
<b>Length</b>	
1 inch = 0.0833 foot	1 foot = 12 inches
1 foot = 0.3333 yard	1 yard = 3 feet
1 mile = 5,280 feet	1 foot = 1.8939x10 <sup>-4</sup> mile
1 mile = 1,760 feet	1 yard = 5.6818x10 <sup>-4</sup> mile
<b>Pressure</b>	
1 pound/square inch = 2.31 feet of water	1 foot of water = 0.4333 pounds/square inch
<b>Velocity</b>	
1 foot/second = 0.6818 mile/hour	1 mile/hour = 1.4667 feet/second

**Table E-2**  
**Typical Water Industry USCS Conversion Factors**  
*Continued*

<b>Volume</b>	
1 quart = 0.25 gallon	1 gallon = 4 quarts
1 cubic inch = $5.787 \times 10^{-4}$ cubic foot	1 cubic foot = 1728 cubic inches
1 cubic foot = 0.0370 cubic yard	1 cubic yard = 27 cubic feet
1 cubic foot = 7.4805 gallons	1 gallon = 0.1337 cubic foot
1 acre-foot = 43,560 cubic feet	1 cubic foot = $2.2956 \times 10^{-5}$ acre-foot
1 acre-foot = 0.3259 million gallons	1 million gallons = 3.0689 acre-feet

<b>Weight</b>	
1 ounce = 0.0625 pound	1 pound = 16 ounces
1 ton = 2000 pounds	1 pound = $5 \times 10^{-4}$ ton

**Table E-3**  
**Typical Water Industry USCS to Metric Conversion Factors**

<b>Area</b>	
1 square inch = 6.415 square centimeters	1 square centimeter = 0.155 square inch
1 square foot = 0.0929 square meter	1 square meter = 10.7639 square feet
1 square yard = 0.8361 square meter	1 square meter = 1.196 square yards
1 acre = 0.4047 hectare	1 hectare = 2.471 acres
1 acre = 0.0040 square kilometer	1 square kilometer = 247.1 acres
1 square mile = 2.59 square kilometers	1 square kilometer = 0.3861 square mile

<b>Flowrate</b>	
1 gallon/minute = 0.063 liter/second	1 liter/second = 15.8730 gallons/minute
1 cubic foot/second = 28.2763 liters/second	1 liter/second = 0.0354 cubic foot/second

<b>Force</b>	
1 pound(f) = 4.4482 Newtons	1 Newton = 0.2248 pound(f)

<b>Length</b>	
1 inch = 25.4 millimeters	1 millimeter = 0.03937 inch
1 inch = 2.54 centimeters	1 centimeter = 0.3937 inch
1 foot = 0.3048 meter	1 meter = 3.2808 feet
1 yard = 0.9144 meter	1 meter = 1.0936 yards
1 mile = 1.6093 kilometers	1 kilometer = 0.6214 mile

<b>Power</b>	
1 horsepower = 0.746 kilowatt	1 kilowatt = 1.341 horsepower

<b>Pressure</b>	
1 pound/square inch = 6.8948 kilopascals	1 kilopascal = 0.1450 pound/square inch
1 pound/square foot = 47.8803 kilopascals	1 kilopascal = 0.0209 pound/square foot

<b>Temperature</b>	
1 Deg Fahrenheit = 1.8 (Deg Celsius +32)	1 Deg Celsius = 0.5556 (Deg Fahrenheit -32)

<b>Velocity</b>	
1 foot/second = 0.3048 meter/second	1 meter/second = 3.2808 feet/second

**Table E-3**  
**Typical Water Industry USCS Conversion Factors**  
*Continued*

<b>Volume</b>	
1 cubic inch = 16.387 cubic centimeters	1 cubic centimeter = 0.0610 cubic inch
1 cubic foot = 0.0283 cubic meter	1 cubic meter = 35.3134 cubic feet
1 cubic yard = 0.7646 cubic meter	1 cubic meter = 1.3079 cubic yards
1 quart = 0.9463 liter	1 liter = 1.0567 quarts
1 gallon = 0.2646 liter	1 liter = 3.78 gallons
<b>Weight</b>	
1 ounce = 28.3495 grams	1 gram = 0.0353 ounce
1 pound = 0.4536 kilogram	1 kilogram = 2.2046 pounds
1 ton = 907.1848 kilograms	1 kilogram = 0.0011 ton

**4. REFERENCES**

- A. Should the reader have any suggestions or questions concerning the material in this section, contact one of the member agencies listed.
  
- B. The publications listed below form a part of this section to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said publications unless otherwise called for. The following list of publications, as directly referenced within the body of this document, has been provided for the users convenience. It is the responsibility of the user of these documents to make reference to and/or utilize industry standards not otherwise directly referenced within this document.

END OF SECTION