NBSIR 76-1020

Guide Criteria for Laboratory Evaluation of Backflow Prevention Devices for Protection of Potable Water Supplies

Grover C. Sherlin
Robert W. Beausoliel
Lawrence S. Galowin

Center for Building Technology
Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

March 1976

Final Report

Prepared for
The Office of Water Supply
Environmental Protection Agency
Washington, D. C. 20460

NBSIR 76-1020

GUIDE CRITERIA FOR LABORATORY EVALUATION OF BACKFLOW PREVENTION DEVICES FOR PROTECTION OF POTABLE WATER SUPPLIES

Grover C. Sherlin
Robert W. Beausoliel
Lawrence S. Galowin

Center for Building Technology
Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

March 1976

Final Report

Prepared for
The Office of Water Supply
Environmental Protection Agency
Washington, D. C. 20460

U.S. DEPARTMENT OF COMMERCE, Elliot L. Richardson, *Secretary*
Dr. Betsy Ancker-Johnson, *Assistant Secretary for Science and Technology*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

CONTENTS

GUIDE CRITERIA FOR LABORATORY EVALUATION OF BACKFLOW PREVENTION DEVICES FOR PROTECTION OF POTABLE WATER SUPPLIES

GROVER C. SHERLIN, ROBERT W. BEAUSOLIEL AND LAWRENCE S. GALOWIN

ABSTRACT

This report describes laboratory evaluation procedures which could be required for the approval of backflow prevention devices used to protect potable water supplies against contamination. Performance-based requirements, criteria, and general evaluation considerations that administrative authorities should require for approval of devices are presented. Recommendations for the development of tracer tests are submitted for further consideration. This document results from an investigation undertaken for the Environmental Protection Agency (EPA).

Key Words: Backflow; backflow prevention devices; back pressure; backsiphonage; guide criteria; potable water protection; plumbing guide criteria; water supply.

1.0 INTRODUCTION

1.1 Purpose

The Office of Water Supply of the Environmental Protection Agency (EPA) assists local (usually municipal) authorities, through State Water Supply Agencies, in establishing and operating cross-connection programs to prevent pollution of potable water supplies. An essential part of these programs is to suggest model language for the adoption into ordinances which would require that suitable backflow prevention devices be used to protect potable water supplies from contamination. The ordinances usually require that such protective devices be approved by the authority having jurisdiction or be certified by a recognized testing laboratory. Few municipalities can afford to operate facilities to test and evaluate these devices, and the known certifying laboratories are few in number. The present standards for backflow prevention devices are considered to be incomplete and inadequate for evaluation of innovative devices, therefore EPA has requested that NBS develop the GUIDE CRITERIA[1/] presented within this document.

1/ A number of terms have been defined in Section 6.0

1.2 Scope

1.2.1 The backflow protection devices and piping arrangements identified in plumbing codes are (1) the air gap, (2) the barometric loop, (3) the atmospheric-type vacuum breakers (4) the pressure-type vacuum breakers, (5) double check valve backflow preventer, and (6) the reduced pressure principle backflow preventer.

1.2.2. This document provides detailed requirements, criteria and test procedures for backflow preventers operating on the reduced pressure principle. The format used in this document for presentation of criteria could be used for other types of backflow preventers.

2.0 SELECTION OF FORMAT FOR THE CRITERIA

2.1 Reference Standards

Of the four standards currently in use for reduced pressure principle backflow preventers, the A.S.S.E. Standard 1013 "Performance Requirements for Reduced Pressure Principle Back Pressure Backflow Preventers" [1] 2/ because of its arrangement of contents has the best format for development into performance-standard style. Contents of the A.S.S.E. 1013 are compared with the latest edition of Section 10 of the Manual of Cross-Connection Control, 5th Edition, March 1974 "Specification for Backflow Prevention Devices" [2] and are contained in the Appendix to this document as Section 8.

It can be seen from the indexed comparison that the subject matter in the Manual of Cross-Connection Control is more detailed than that of the A.S.S.E. Standard 1013. Although a careful examination of both of the standards identifies shortcomings and imperfections, each standard has valuable content which has been incorporated into the criteria which are contained in Section 3.

2.2 Essential Contents of Standards

2.2.1 The type of material needed in a standard for backflow preventers is not significantly different from that needed for standards for other mechanical devices. A checklist concerned with the essential contents of such standards would pose the following considerations:

2/ Numbers in brackets refer to sequential listing of references in Section 7

1. The scope and purpose must be clearly stated.

2. The standard must provide guidance on such matters as the need for drawings or for test data to aid in the evaluation of the device.

3. The standard must indicate procedures for obtaining approval of the device including the requirement for laboratory and/or field testing and the selection of specimens for testing.

4. The limitations on the design of the device should be stated as principles rather than prescriptions.

5. It should be clearly specified whether the device is to be repairable for extended service life or is to be replaced and discarded when it becomes defective.

6. The limitations on the use of materials should be defined in terms of anticipated lifespan of the device and of the required efficiency of the device in service with particular consideration of unusual deterioration or degredation of materials.

7. The hydraulic, mechanical and pneumatic performance requirements and criteria must be clearly and concisely stated.

8. The test methods must be stated precisely and free of ambiguity.

9. The bases for rejection of the device must be clearly stated.

10. Instructions should be given for marking of the devices as may be needed for installation and for identification.

11. Instructions for installing the device should be supplied with each packaged item and such instructions should be subject to editorial review, for clarity, as part of the evaluation of the device.

12. Definitions must be provided as an aid to producers, distributors, designers, engineers, installers, inspectors, and users of the device.

2.2.2 A brief study of the above checklist suggests some broad grouping of the subject matter: Classification of Device and Purpose, Limitations on Design and Materials, Criteria and Procedures for Evaluation, Instructions for Marking and Installation, and Definitions and References.

2.2.3 Generally it is desired that the contents of the standards appear in a language with wording that is definitive but not restrictive. However, for many items limitations of technology are encountered that cause authors of the standards to prescribe only designs and materials that have been found by experience to be successful and to exclude those for which there is yet no successful experience. By the unfortunate choice of such wording, innovations are consequently locked out of considerations.

2.3 The Performance-based Format

2.3.1 In the performance-based format of standards, four elements have been used frequently: (1) Requirement, (2) Criterion, (3) Method of Evaluation and (4) Commentary. The limitations on design and material are stated as a "Requirement" usually without use of numerical specifications. A "Criterion" is a restatement of the Requirement with the incorporation of numbers and factors that can be measured in an evaluation process. In the "Method of Evaluation" the test procedures are clearly presented and the basis for acceptance or rejection is stated. A "Commentary" may be helpful to justify or explain the requirement, the criterion or the method of evaluation. Brevity of language sometimes causes misunderstanding in different regions of the country and the commentary can thereby help define and amplify the intent of the authors of the standard.

2.3.2 The criteria presented in Section 3 are intended to be technically self-contained. If extracted from this report some additional information must accompany it to explain its purpose and application.

3.0 CRITERIA FOR THE EVALUATION OF REDUCED PRESSURE PRINCIPLE BACK PRESSURE BACKFLOW PREVENTERS

3.1 Scope

3.1.1 Class of Devices

This standard applies to only the type of backflow prevention devices identified as "Reduced Pressure Principle Backflow Preventers." These devices consist of two independently acting check valves, internally force loaded to a normally closed position, and separated by an intermediate chamber (or zone) in which there is an automatic relief means for venting to atmosphere, internally force loaded to a normally open position. These devices are designed to operate under continuous pressure conditions. (ASSE)[a/] [a]

---

a/ By the use of abbreviations enclosed in parenthesis (ASSE) gives credit to American Society of Sanitary Engineering, (FCCCHR) gives credit to Foundation for Cross-Connection Control and Hydraulic Research and (NBS) gives credit to the authors and reviewers at the National Bureau of Standards. (Letters in brackets refer to References in Section 3.6).

3.1.2 Size

Connection pipe sizes (i.p.s.)[b/] in inches are 1/4, 3/8, 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 4, 6, 8, 10, 12, 14, and 16. (FCCCHR) [b]

3.1.3 Working Pressure

Devices shall be designed for a working pressure of at least 150 psi. (ASSE)

3.1.4 Temperature Range

(a) Cold water devices: from 33°F up to 110°F.

(b) Hot water devices: water temperature above 110°F. (ASSE, NBS)

3.1.5 Purpose

The purpose of a backflow preventer is to keep contaminated water from flowing back into a potable water distribution system when some abnormality in the system causes the pressure to be temporarily higher in the contaminated part of the system than in the potable water piping (NBS).

3.2 Limitations on Design and Materials

3.2.1 Flow Capacity

The waterway in the device shall be as free as possible from obstructions and pockets which could interfere with the free flow of water. (FCCCHR, NBS)

3.2.2 Structural Strength

All parts of the device shall be designed to withstand without permanent distortion, the stresses developed by the specified hydrostatic test pressure, as well as the stresses resulting from a specified water working pressure coincident with operation under a specified unbalanced pressure condition. (FCCCHR, NBS)

3.2.3 Mechanical Function

3.2.3.1 The moving parts shall have adequate clearance to prevent binding or galling, or to prevent the device from becoming inoperative by being thrown out of balance, by being distorted, by having one part interfere with another, or by becoming

---

b/ A number of terms applicable to the criteria have been defined in Section 3.5.

encrusted with lime, rust, or scale deposits. (FCCCHR)

3.2.3.2 All moving parts shall be designed to operate up to the rated flow without chatter or vibration. (FCCCHR)

3.2.3.3 The operation of the device shall not cause water hammer. (FCCCHR)

3.2.4 Misassembling

The design shall be such that the parts cannot be easily misassembled (ASSE).

3.2.5 Evidence of Failure at Barriers

Diaphragms or bellows used as barriers in control piping which by-pass one or more check valves shall be installed in such a manner that, in case of failure, visible evidence of failure will be produced. (ASSE, NBS)

3.2.6 Location of Test Cocks

Test cocks shall be provided in the device upstream of the inlet check valve, in the downstream end of the outlet check valve, in the intermediate chamber, and on the inlet side of the supply shut-off valve. (ASSE)

3.2.7 Collection of Debris at Relief Valve Opening

3.2.7.1 Relief valve discharge outlet shall be protected against the collection of debris which could reduce the flow area and adversely affect the performance of the device. (ASSE)

3.2.7.2 The relief valve discharge port shall not be of a size that can be threaded for iron pipe size or connected with tubing either internally or externally. (FCCCHR)

3.2.8 Leakage

All joints shall be watertight where subject to water pressure. (FCCCHR)

3.2.9 Repairability

3.2.9.1 The internal parts of the devices shall be accessible for inspection, repairs or replacements. For pipe sizes larger than 2-inch, the design shall permit this servicing without removing the devices from the line. (ASSE, NBS)

3.2.9.2 All replaceable parts of assemblies of the same size and model shall be interchangeable with the original parts. (FCCCHR)

3.2.10 Release of Trapped Air

Provisions shall be made for bleeding trapped air from the highest point of the device when the normal flow of water will not displace it. (FCCCHR)

3.2.11 Corrosion Resistance

In all cases where it is impossible to use similar metals in the construction of backflow preventers, steps shall be taken, insofar as practicable, to prevent the formation of electrolytic galvanic couples. (FCCCHR)

3.2.12 Durability

A reasonable planned life expectancy of the backflow preventer and its parts should be incorporated in the design. (NBS)

3.2.13 Toxic Materials

Materials which could contaminate the water and make it injurious to persons consuming it shall not be used in the device where the material would be in contact with the water. (NBS)

3.3 Criteria and Procedures for Evaluation [c/]

3.3.1 Drawings

Assembly drawings and other data which are needed to enable a testing agency to determine compliance with this standard, together with installation drawings, shall accompany devices when submitted for examination and performance tests under this standard. (ASSE)

3.3.2 Laboratory Testing

One or more units, selected at random from the manufacturer's stock, of each size and model shall undergo a complete laboratory evaluation of its design and operating characteristics including hydrostatic tests at an approved laboratory. (FCCCHR)

---

c/ Sections 3.3 and 3.4 utilize material found mainly in A.S.S.E. Standard 1013.

3.3.3 Field Evaluation

3.3.3.1 Field evaluation of a backflow preventer as a prerequisite to acceptance at time of purchase is an optional requirement that should be agreed upon contractually between buyer and seller (see Section 3.3.14, Field Testing). (NBS)

3.3.4 Hydrostatic test of Complete Housing

3.3.4.1 The device shall show no leaks or indications of damage when subjected to a hydrostatic pressure of two (2) times the rated working pressure applied at the inlet.

3.3.4.2 Install as in Fig. 1. Purge the system of air and pressurize to test pressure. Hold for five (5) minutes. Observe for external leaks or other indications of damage.

3.3.4.3 Any leaks or indications of damage shall be cause for the rejection of the device.

3.3.5 Hydrostatic Test of Outlet Only

3.3.5.1 A pressure of two (2) times the rated working pressure applied to the outlet of the device with inlet and intermediate chamber pressure at atmospheric shall cause no leakage or damage to the check valve which will adversely affect its capability for complying with the other requirements of this standard.

3.3.5.2 Following the test of paragraph 3.3.4.2, drop the supply pressure to atmospheric, while holding the outlet pressure at two (2) times the rated working pressure for ten (10) minutes.

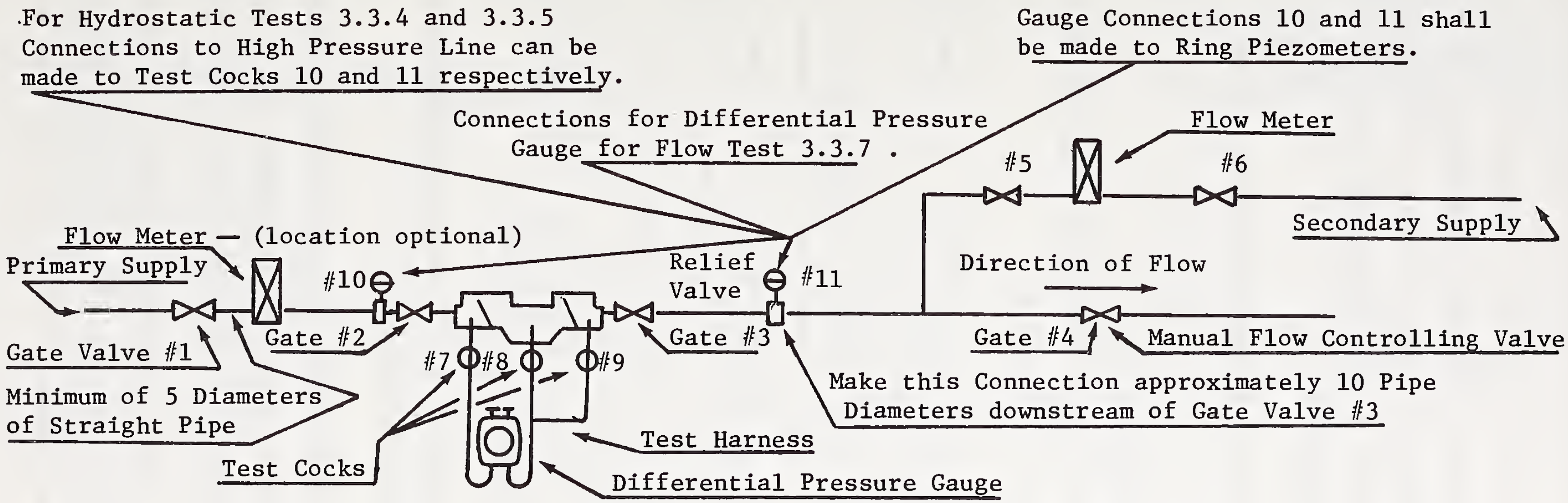
3.3.5.3 Any observed conditions of damage or continuous discharge from the intermediate chamber relief valve shall be cause for rejection.

3.3.6 Drip Tightness of Outlet Check Valve

3.3.6.1 The outlet check valve shall be drip tight as evidenced by no loss of level in the sight glass below 28" when the intermediate pressure is 1 psi and the outlet pressure is atmospheric.

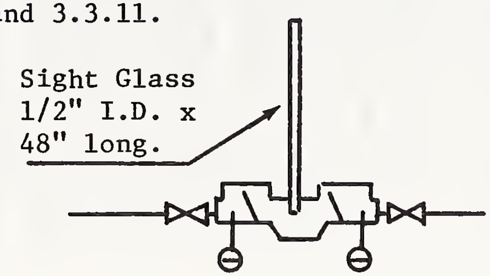
3.3.6.2 With the device installed as in Fig. 1, attach a transparent tube, not less than 48" long, to the intermediate chamber test cock tapping as shown in Fig. 2. Fill the

Figure 1. An Adaptation from A.S.S.E. 1013 [a] to Provide the Schematic Piping Layout for the Tests Described in Subsection 3.3 .



Note: For Test 3.3.9 a sight glass installed as in Figure 2 or a suitable pressure gauge may be used at Point 8.

Figure 2. An Adaptation from A.S.S.E. 1013 [a] to Identify the Location of the Sight Glass Required in Tests 3.3.6 and 3.3.11.



system and purge it of air. Valves 3 and 4 must remain open. Admit water slowly through the inlet until the water level in the tube is at least 42" measured from the center of the pipe line or the center of the disc face, whichever is appropriate. Close the supply valve tightly and hold in a closed position for five (5) minutes. During the test all external connections shall be observed for the detection of leaks which would affect accurate test results and the leaks eliminated.

3.3.6.3 Any loss of level in the sight glass below 28" shall be cause for rejection of the device.

3.3.7 Allowable Pressure Loss at Rated Flow

3.3.7.1 The required rated water flow shall be obtained at or below the maximum allowable pressure loss shown in Table 1 for ASSE 1013.

3.3.7.2 Install the backflow prevention device as in Fig. 1 with gauge cocks 7, 8, and 9 closed and a manometer or differential pressure gauge connected to positions 10 and 11. These connections shall be to ring piezometers. The supply source shall be capable of supplying a volume of water adequate to meet the flow requirements of the size of device on test and maintain an inlet pressure of at least 10 psi greater than the allowable pressure loss at rated flow. Purge the system of air, then gradually increase the flow of water through the device until the required rated flow of water is achieved or the maximum allowable pressure loss is reached. The pressure loss through valves and piping between the device on test and gauges 10 and 11 must be subtracted from the differential pressure reading between gauges 10 and 11.

3.3.7.3 Failure to obtain the rated flow at or below the maximum allowable pressure loss shall be cause for rejection of the device.

3.3.8 Intermediate chamber (or Zone) Pressure vs. Inlet Pressure for Flowing Status

3.3.8.1 When operating under either static or flow conditions, the intermediate zone pressure shall be at least 2 psi lower than the pressure in the inlet of the device.

3.3.8.2 Install the device as in test system Fig. 1. During forward flow of water through the device the difference between the inlet pressure and the intermediate chamber pressure shall be observed and recorded. For the static test close downstream

Table 1 A comparison of the maximum allowable pressure loss at rated flow for backflow prevention devices as found in existing standards.

Size of Device	Rated Flow	Maximum Allowable Pressure Loss at Rated Flow, psi.				
		ASSE 1013 June, 1971 [a]	ASSE 1013 Jan.,1978 [a]	AWWA C506 Jan.,1969 [c]	IAPMO PS 31-74 [d]	Foundation for Cross Connection Control and Hydraulic Research March 1974 [b]
inches	gpm					
1/4	5	-	-	-	-	24
3/8	8	-	-	-	-	22
1/2	12	22	22	34	22	22
3/4	30	34	20	34	20	20
1	50	34	18	34	18	18
1-1/4	75	34	18	34	18	18
1-1/2	100	34	16	34	16	16
2	160	25	16	25	16	16
2-1/2	225	25	16	25	16	16
3	320	25	15	25	15	15
4	500	25	14	25	14	14
6	1000	25	14	25	14	14
8	1600	25	14	25	14	14
10	2300	25	14	25	14	14
12	3000	13	13	--	--	13
14	3700	13	13	--	--	13
16	4400	13	13	--	--	13

valve 3, upstream valve 1, and observe the pressure difference between the inlet and intermediate chamber pressure. Hold in static condition for five (5) minutes.

3.3.8.3 A pressure difference of less than 2 psi during either flowing or static conditions shall be cause for rejection of the device.

3.3.8.4 Any reduction of differential pressure would indicate an internal leak between the inlet and intermediate chamber.

3.3.9 Intermediate Chamber (or Zone) Pressure vs. Inlet Pressure for Static Status

3.3.9.1 Where there is a static operating condition and the supply pressure falls off to 2 psi, the pressure in the intermediate chamber, or zone, shall become atmospheric.

3.3.9.2 With the device installed as in Fig. 1, install a suitable pressure gauge at #8 in combination with the intermediate chamber connection to the differential gauge. Open the supply valve to purge the system of air, close test cock #9 and valve #3, raise pressure in the inlet of the device to approximately 25 psi and close valve #1. Slowly bleed down the inlet pressure to open the relief means and allow water to discharge from the intermediate chamber to atmosphere, and immediately close the bleed valve.

3.3.9.3 A pressure of less than 2 psi indicated by the differential gauge shall be cause for rejection of the device.

3.3.10 Relief Discharge Rate during Backflow Condition, supply pressure 2 psi or more.

3.3.10.1 Where there is backflow and the supply pressure is 2 psi or greater, the relief valve shall discharge water from the intermediate chamber (or zone) to atmosphere at the rate of discharge corresponding to the data shown in Table 2 for ASSE 1013 and the pressure in the zone shall be at least 0.5 psi below supply pressure.

3.3.10.2 Install the device as in Fig. 1 with test harness. By mechanical means hold the outlet check valve wide open. Install a gauge in test cock 10 and open test cocks 7 and 8. Purge the air and pressurize the system to approximately 25 psi inlet pressure. Close supply valve 1 and downstream valve 4. Open supply valve 5 in the secondary water supply, then slowly open valve 6 until the specified rate of discharge from the relief valve is reached, as shown in Table 2 for ASSE 1013. Observe and record

Table 2. A comparison of minimum flow rates through relief valve, as covered by four standards, and the corresponding minimum diameter through passageways of relief valve openings.

Size of Device	Minimum Flow Rates Through Relief Valves	Minimum Diameter Through Passageways of Relief Valve Openings, inches			
		ASSE 1013 June, 1973 [a]	AWWA C506 June, 1969 [c]	IAPMO PS 31-74 [d]	Foundation for Cross-connection Control and Hydraulic Research March, 1974 [b]
inches	gpm				
1/4 and 3/8	1.5 c/	---	---	---	---
1/2 and 5/8	3	3/8	1/2	3/8	3/8
3/4 and 1	5	1/2	1/2	1/2	1/2
1-1/4 and 1-1/2	10	3/4	3/4	3/4	3/4
2 and 2-1/2	20	1	1	1	1
3	30	1-1/4	1-1/4	1-1/4	1-1/4
4 and 6	40	1-1/2	1-1/2	1-1/2	1-1/2
8 and 10	60	2	2	2	2
12	75	2-1/2	---	---	2-1/2
14	90	3	---	---	3
16	100	3	---	---	3

d/ By an extrapolation of the above data, the authors obtained a value of 1.5 gpm for the minimum flow rate through the relief valve and a value of 1/4 inch for the minimum diameter of passageway of the relief valve, for sizes 1/4 and 3/8 inches.

the supply pressure and the differential pressure.

3.3.10.3 A pressure differential between the inlet and intermediate chamber of less than 1/2 psi, as measured by the differential gauge, shall be cause for rejection of the device.

3.3.11 Relief Discharge Rate during Backflow Condition, supply pressure less than 2 psi.

3.3.11.1 When there is backflow and the supply pressure is less than 2 psi, the relief valve shall discharge water from the zone to atmosphere with the rate of discharge corresponding to the data shown in Table 2 for ASSE 1013 and the pressure in the zone shall not exceed 1.5 psi.

3.3.11.2 Close the secondary supply valve 5. Disconnect the test harness from test cocks 7 and 8. Install a sight glass on test cock 8 as shown in Fig. 2. Allow inlet pressure to fall to atmosphere via test cock 7. Open supply valve 5 in the secondary water supply line slowly until the specified rate of discharge from the relief valve is reached as shown in Table 2 for ASSE 1013. Observe and record the pressure shown on the sight glass.

3.3.11.3 A pressure greater than 42" of water shall be cause for rejection of the device.

3.3.12 Relief Valve Opening and Closing

3.3.12.1 The pressure relief or atmospheric vent valve shall not start to open until the pressure in the intermediate chamber is at least 2 psi lower than the pressure in the inlet of the device. It shall open and close positively.

3.3.12.2 Install the device as in Fig. 1, including a by-pass with a needle valve between test cocks 7 and 8. Purge the system of air and pressurize the system to approximately 25 psi. Open slightly the needle valve in the by-pass until the gauge shows a decreasing differential pressure.

3.3.12.2(a) Close the needle valve and open the supply valve to restore the inlet pressure. The relief valve must reclose tightly.

3.3.12.3 A reading of less than 2 psi at the time of opening of the relief valve shall be cause for the rejection of the device.

3.3.12.3(a) Failure of the relief valve to close drip tight shall be cause for the rejection of the device.

3.3.13 Relief Valve Discharge vs. Inlet Pressure Surge

3.3.13.1 The relief valve shall not discharge water under supply pressure fluctuation of ± 1-1/2 psi maximum variation.

3.3.13.2 Install the device as in Fig. 1. Purge the system of air and pressurize to approximately 25 psi static pressure in the inlet of the device. Within a 10 second period change the inlet pressure to +(1-1/2) psi, then to -(1-1/2) psi and back to the static pressure level.

3.3.13.3 Any discharge from the relief valve during these tests shall be cause for rejection of the device.

3.3.14 Field Testing [e/]

Field Testing is an essential procedure in a cross-connection control program, and to facilitate periodic testing of a backflow preventer while it is installed in a potable water line, test cocks as described in paragraph 3.2.6 are essential for the following tests:

3.3.14.1 To test operation of pressure differential relief valve.

3.3.14.1.1 The pressure differential relief valve must operate to maintain the "zone" between the two check valves at least 2 psi less than the supply pressure.

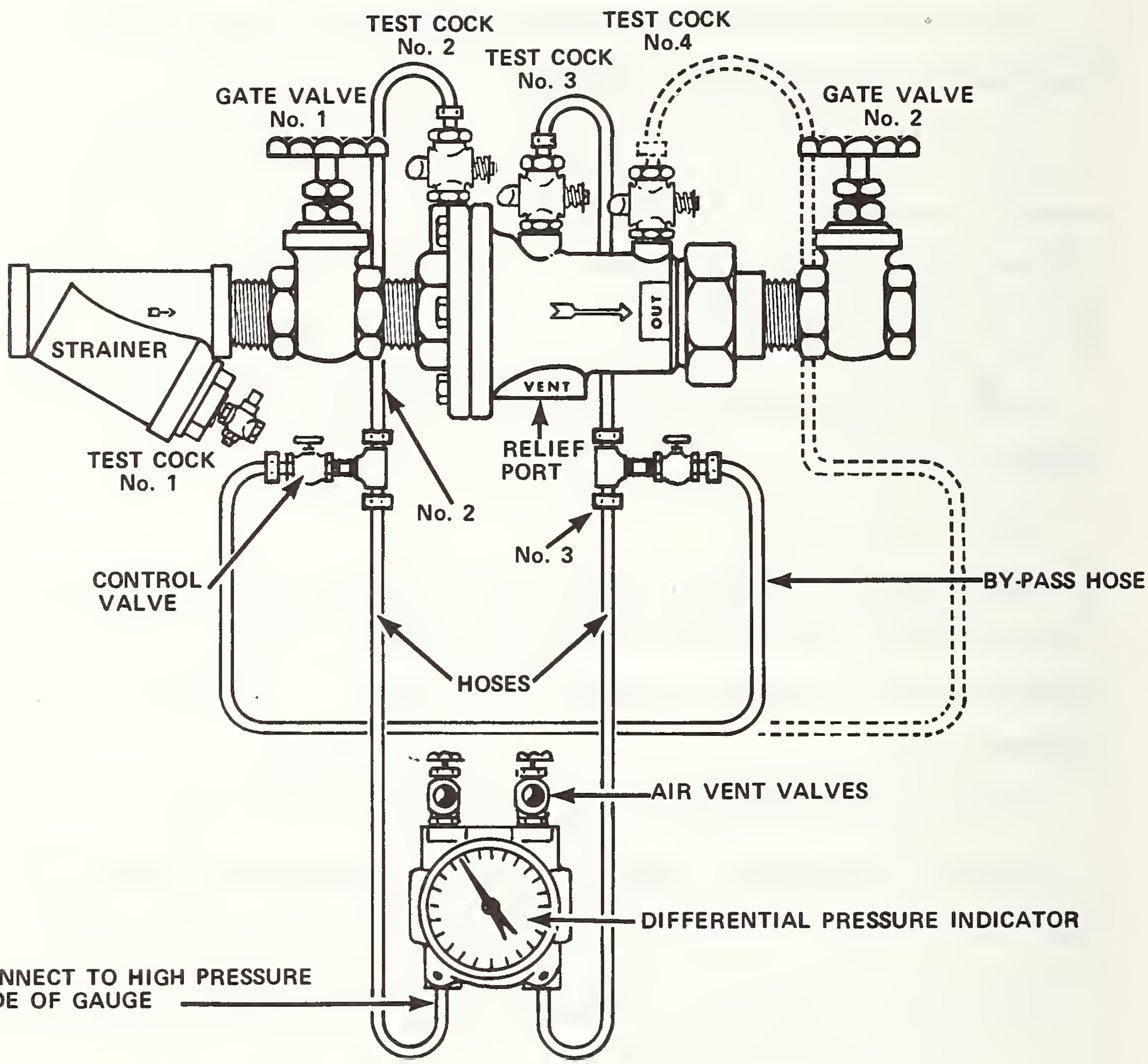
3.3.14.1.2 a. Connect test equipment as shown in Fig. 3. Close gate valve No. 2. Open gate valve No. 1.

b. Install bypass hose from test cock No. 2 through a control valve to test cock No. 3.

---

e/ This subsection on field testing is credited to Bulletin F-FT (May 1971) "Field Testing Procedure" of Watts Regulator Co. Lawrence, Mass. 01842

Fig. 3. Drawing to show instrument and connecting hose needed for field testing of a reduced pressure zone backpressure backflow preventer.



c. Connect one differential pressure gauge lead to test cock No. 2; connect other differential pressure gauge lead between the control valve on the bypass line and test cock No. 3.

d. Open test cocks No. 2 and No. 3 and vent the differential pressure gauge.

e. Open the control valve on the bypass hose slowly and note the differential pressure gauge differential at the initial opening of the pressure differential relief valve.

3.3.14.1.3 The reading on the pressure differential gauge should be 2 psi or greater when the pressure differential relief valve initially starts to drip.

3.3.14.2 To test Check Valve No. 1 for tightness against reverse flow

3.3.14.2.1 Valve must be tight against reverse flow under all pressure differentials.

3.3.14.2.2 a. Close gate valve No. 2. Open gate valve No. 1.

b. If there is no discharge from the pressure differential relief valve, the check valve No. 1 shall be noted as "Closed Tight." If there is discharge, the check valve No. 1 shall be noted as "Leaking."

3.3.14.2.3 If the test of Check Valve No. 1 or Check Valve No. 2 (below) gives indication by discharge of water that the check valve is leaking, investigate the condition of the relief valve and seat before repairing check valve.

3.3.14.3 To test check valve No. 2 for tightness against reverse flow

3.3.14.3.1 Valve must be tight against reverse flow under all pressure differentials.

3.3.14.3.2 a. Close gate valve No. 2. Open gate valve No. 1.

b. Close test cock No. 3.

c. Install the bypass hose from test cock No. 2 to test cock No. 4.

d. Open test cocks 2 and 4.

3.3.14.3.3 If water is discharged from the pressure differential relief valve, the check valve No. 2 shall be noted in the report as "Leaked." If no water is discharged the check valve shall be noted as "Closed Tight."

3.4 Instructions for Marking and Installation

3.4.1 Marking of Devices

3.4.1.1 Each device shall have the following information marked on it where it will be visible after the device has been installed:

(a) Name of manufacturer or trademark

(b) Type and model number of the device

(c) Maximum rated working pressure

(d) Maximum water temperature for which the device is designed.

(e) Date of manufacture or serial number or other marking consistent with the manufacturer's standard practice.

(f) Inlet and outlet connection pipe size.

(g) The direction of water flow through the device shall be shown.

3.4.1.2 The markings shall be either cast, etched, stamped or engraved on the body of the device or on a durable metal plate securely attached to the device.

3.4.2 Installation Instructions

3.4.2.1 Complete instructions for installation of the device must be packaged with it. Drawings or schematic sketches which would be useful to the installer should be part of these instructions. These instructions must provide all information necessary to allow a correct installation.

3.4.2.2 These instructions shall show a shut-off valve installed both upstream and downstream of the device to enable field testing.

3.4.2.3 The installation instructions shall indicate that a test cock be provided on the inlet side of the supply shut-off valve.

3.4.2.4 It is recommended that a suitable strainer be installed closely upstream of the device.

3.5 Definitions

Atmospheric Air: Air of the surrounding atmosphere and at its existing pressure. (ASSE) f/

Backflow: The unintentional reversal of flow in a potable water distribution system which may result in the transport of harmful materials or substances into the other branches of the distribution system. (NBS)

Backflow Preventer: Any mechanical device, whether used singly or in combination with other controls, designed to automatically prevent an unintentional reverse flow in a potable water distribution system. (ASSE,NBS)

Backflow Preventers, Reduced Pressure Principle, Back Pressure: These devices consist of two independently acting check valves, internally force loaded to a normally closed position, and separated by an intermediate chamber (or zone) in which there is an automatic relief means for venting to atmosphere, internally force loaded to a normally open position. These devices are designed to operate under continuous pressure conditions. (ASSE)

Back Pressure: Pressure created by any means in the water distribution system on the premises, which by being in excess of the pressure in the water supply main could cause backflow. (NBS)

Contamination: The admission of contaminants into a potable water supply. (ASSE)

Contaminants: Any material (solid or liquid or gas) which if introduced into a potable water supply, would cause it to be unfit for human or animal consumption. (ASSE, NBS)

Control Valve: A valve that is operated each time water is supplied to or shut off from a receptacle or plumbing fixture. Familiar examples are faucets and sill cocks. (ASSE)

Hazard: A possible source of danger or peril; also a condition that tends to create or increase the possibility of loss or harm. (NBS)

Hazard, Health: An actual or potential threat, of contamination or pollution of a physical or toxic nature to the potable water system to such a degree that there would be a danger to health. (FCCCHR)

Hazard, Minimal: A connection made to the potable water system whereby the risk from backflow occurring would be limited to the contamination of the potable water with objectionable but non-toxic substances such as steam, air, food, beverage etc. (NBS)

Health Agency: The organization established by law to have jurisdiction over the water supply quality. (FCCCHR)

---

f/ Sources of definitions are identified as follows:

(ASSE) - American Society of Sanitary Engineering
(FCCCHR) - Foundation for Cross-Connection Control and Hydraulic Research
(NBS) - National Bureau of Standards (U. S.) If the acronym is used jointly with either (ASSE) or (FCCCHR) the authors or reviewers have opted to modify an existing definition.

i.p.s. (iron pipe size): The approximate inside diameter of pipe for sizes up to 12" inclusive. For larger diameters the size refers to the outside diameter. (NBS) Pipe in these sizes may be made from several materials such as steel, brass, copper, plastic, etc.

Piezometer: A piezometer is a device for the measurement of pressure in pipes or conduits, consisting of a vertical transparent tube which is connected at its lower end to a piezometer orifice in the wall of the pipe or conduit and is open to atmosphere at its upper end. The height to which fluid rises in the transparent tube is a measure of the head or pressure in the pipe or conduit. (NBS)

Piezometer Orifice: A piezometer orifice is a small hole through the wall of a pipe or conduit drilled at a 90° angle to the wall and carefully finished at the inner edge of the hole. (NBS)

Potable Water: Water from any source which has been approved for human consumption by the health agency having jurisdiction. (FCCCHR)

Pollution: As used in this report the word is equivalent to contamination. FCCCHR credits the California State Health and Safety Code with differentiating the two words: contamination of water creates health hazards and pollution of water creates minimal hazards. (NBS)

Pressure, Atmospheric: The pressure exerted in every direction at any given point by the weight of the atmosphere. (ASSE, NBS)

Pressure, Differential: The difference in pressure between two points in the fluid carried by a piping system.

Pressure, Hydrostatic: Pressure exerted by or existing within a liquid at rest with respect to adjacent bodies. (Webster 3rd International)

Pressure, Working: The pressure at which the water supply system nominally operates. It is a lower pressure than the setting of pressure relieving devices in the system in order to prevent their frequent opening. Such safety devices are set at the maximum allowable working pressure. (ASME, NBS) In the same context, a hydrostatic test pressure for the system could be stated to be twice the working pressure whereas the destruction test pressure might be three to five times the working pressure, depending on design considerations.

Rated Flow: An empirical value of a flow rate in gallons per minute (gpm) that has been established within the industry as a reasonable value for characterizing the capacity of each size of backflow preventer and for specifying certain performance characteristics. (NBS)

Toxic: Poisonious (see Code of Federal Regulations, Title 21, Food and Drugs Parts 170 to 299, 21 CFR 170.1, Section 191.1, Hazardous Substances. Definitions). (ASSE)

Water Hammer: The term used to identify the hammering noises and severe shocks that may occur in a pressurized water supply system when flow is halted abruptly by the rapid closure of a valve or faucet. (NBS)

Water Purveyor: The owner or operator of the public potable water system supplying an approved water supply to the public. The purveyor operates under a valid permit from the State Department of Public Health or the local health agency having jurisdiction. (FCCCHR)

Water Supply Approved: Any public potable water supply which has been investigated and approved by the State Department of Public Health or the local health agency having jurisdiction. The system must be operating under a valid health permit. (FCCCHR)

3.6 References

[a] A.S.S.E. 1013, "Performance Requirements for Reduced Pressure Principle Back Pressure Backflow Preventers," American Society of Sanitary Engineering, 228 Standard Building, Cleveland, Ohio, June 1971.

[b] Springer, E. K., "Manual of Cross-Connection Control," Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, Los Angeles, California, 1974.

[c] AWWA C506-69, "Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types," American Water Works Association, New York, 1969.

[d] PS 31-74, "Specification for Backflow Prevention Devices", International Association of Plumbing and Mechanical Officials, Los Angeles, California, 1974.

4.0 UTILIZATION OF GUIDE CRITERIA

4.1 For Updating of A.S.S.E. Standards for Backflow Preventers

The American Society of Sanitary Engineering has developed and published standards for vacuum breakers and for backflow preventers. These standards have been reviewed by members of the A112 Committee of the American National Standard Institute (ANSI). At this phase of the review process numbers have been assigned to each standard for identification within the ANSI cataloging scheme. The cross-referencing of standards are as follows:

[3]	ASSE 1001	ANSI A112.1.1 - 1971
[4]	ASSE 1011	ANSI A112.1.3
[5]	ASSE 1012	ANSI A112.1.4
[1]	ASSE 1013	ANSI A112.1.5
[6]	ASSE 1015	ANSI A112.1.6
[7]	ASSE 1020	ANSI A112.1.7

Provided the approval process moves along without delay these standards may attain ANSI approval, the highest level of national concensus, early in 1976. These guide criteria will point the way to the A.S.S.E. Standards Committee in the task of updating the backflow preventer standards.

4.1.1 Development of Leakage Test at Oak Ridge National Laboratory

One test procedure not included in the A.S.S.E. standards was studied at Oak Ridge National Laboratory around 1965. [8] The following paragraphs are excerpts from the introductory section of the report on these studies:

"The Oak Ridge National Laboratory since the early 1950's has maintained a policy as stated: 'It is the policy of the Laboratory to provide separate distribution systems for potable and process water and to maintain positive physical and mechanical separation of the systems....'"

"As new buildings and facilities were constructed farther from the central complex it became increasingly expensive to extend completely separated potable and process water systems. A reliable means of safely separating potable and process water systems within a building or facility while maintaining pressure became extremely desirable and the reduced pressure principle backflow preventer was investigated...."

"ORNL staff members made a thorough investigation of the status of these devices throughout the country. The fact that there was a wide divergence of opinion among health authorities raised some questions. For example, California accepts approved and properly maintained reduced pressure principle backflow preventers as alternates to air-gap separation in installations where an extreme hazard to life is possible if backflow should occur. These installations include hospitals, mortuaries, morgues, oil refineries, canneries, sewage treatment plants, sewage pumping stations, chemical plants and film laboratories...."

"In contrast seventeen states expressly prohibit any type of cross-connection to potable water supply. Several others make certain exceptions which allow their use. To further evaluate the problem and discover reasons for the divergence of opinion, several ORNL staff members inspected installations in Los Angeles and Los Alamos. They also observed an official test of two backflow preventers conducted by Professor E. K. Springer at the University of Southern California Engineering Center (USCEC). Conferences were held with municipal sanitary engineers to discuss installation, inspection, testing, and maintenance of reduced pressure principle backflow preventive devices...."

"In spite of their acceptance in California and North Carolina, some doubts still remained concerning the adequacy and dependability of these devices in the highly radioactive operations at Oak Ridge National Laboratory. Consequently, a study committee was formed to evaluate the hazards and to establish conditions under which they could be used safely."

"This committee reviewed all previous tests which had been reported. It was determined that sufficient dynamic tests had been performed on the units to prove that properly tested and maintained units would be acceptable under all conditions which would be encountered at ORNL except under conditions where tight shutoff was required for appreciable periods of time, or emergency conditions which would cause interruption of potable water supply and loss of line pressure. To prove acceptability, reliability and safety of the devices under such static conditions, it was decided that five static feasibility tests should be performed under rigidly controlled conditions. The five tests were:

(a) Ionic diffusion

(b) Backflow due to lower pressure on the supply side than on the downstream side

(c) Backflow due to vacuum on the supply side

(d) Backflow due to water hammer on the supply side

(e) Backflow due to water hammer on the downstream side"

"G. W. Leddicotte[3/] suggested using Activation Analysis and non-radioactive solutions containing manganese and potassium because of the greater sensitivity associated with activation analysis compared with methods of analyzing suitable levels of radioactive tracer. An added advantage of this technique was elimination of radiation problems at the test installation. The tracer had a sensitivity of 0.2 parts per billion of manganese and when used with the five tests mentioned above applied to one model RPBD (reduced pressure backflow device) showed that a properly functioning RPBD of this type satisfied the requirements ORNL."

3/ G. W. Leddicotte was an analytical chemist and a research and development group leader in the Analytical Chemistry Division at ORNL 1946-1962. He later joined the faculty of the University of Missouri.

4.1.2 Outline of a Leakage Test Procedure using Non-Radioactive Tracers

Consultation with the NBS Activation Analysis Section has indicated that such tests could have wide spread application for testing all backflow protection devices. Such application should be relatively simple and inexpensive. The tests could be readily carried out by existing testing laboratories after test methods have been worked out and technicians instructed concerning the methods. The basic procedure would be:

(a) Inject a harmless non-radioactive tracer (available at most any chemical supply outlet) downstream of the device.

(b) Perform the necessary flow and pressure changes in the water supply piping (using any of the five tests mentioned above or similar dynamic or cyclic tests to life cycle test the device) in which the device under test is installed.

(c) Sample the upstream side of the device before and after the test and the downstream side after the test.

(d) Send the sample of (c) above to an appropriate laboratory (NBS Activation Analysis Section has indicated that test cost would be relatively low and that the test is relatively simple and expeditious). The appropriate laboratory facility having an atomic reactor would irradiate the samples. After irradiation, the gamma ray count would signify quantitatively the amount of tracer present. Detection threshold measurements as sensitive as 0.2 parts per billion are realized.

(e) If the laboratory tests in (d) above show that the amount of tracer is not in excess of the threshold value, (obtained by measuring the sample taken before the test) the device will have passed the test. Since this is an extremely sensitive test, it may be necessary to establish some acceptable level of tracer detection.

4.2 In the Certification of Testing Laboratories

Sherlin and Beausoliel [9], have pointed out that a National Voluntary Laboratory Accreditation Program is evolving. The Secretary of Commerce will receive and process requests for the establishment of an accreditation Board for any branch of technology. Such a Board would be responsible for accrediting laboratories who might desire to test a product for procurement acceptance. Standards defining test procedures are essential to such testing and adequate standards are required to exist prior to the establishment of an accreditation board. These guide criteria would augment and aid in the clarification of existing standards for backflow preventers.

5.0 SUMMARY

5.1 These guide criteria for the evaluation of Reduced Pressure Principle Back Pressure Backflow Preventers are useful as a framework for a systematic approach to the examination of those requirements that are built into specifications and standards. The requirements can be examined individually and as a whole to acertain that essential matters of health, safety, durability, maintainability and reliability have been adequately incorporated. Frequently special requirements are introduced into specifications as a result of pressure from special interest groups and organizations. Such requirements tend to limit innovations; therefore the desire and the effort here has been to develop performance-based requirements that expand the opportunity for innovation.

5.2 A test developed at Oak Ridge National Laboratory in 1962 appears now, with the advent of low-cost electronic measuring equipment, to be suitable for evaluating the extent of leaking across barriers such as check valves or diaphragms under backflow conditions.

6.0 DEFINITIONS

Because Section 3 was prepared as a model to guide in the writing of criteria for any of the other types of backflow preventers, it was necessary that it be complete within itself. Here in Section 6 only those additional terms are defined that apply in the other Sections of the report.

<u>Administrative Authority</u>: The individual official, board, department, or agency established and authorized by a state, county, city or other political subdivision created by law to administer and enforce the

provisions of the plumbing code as adopted or amended. (NSPC, NBS)[4/]

Air Gap: An air gap in a water distribution system is the unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying potable water to a tank plumbing fixture or other device and the flood level rim of the receptacle. (NSPC)

Air Gap Separation: The physical separation between the free-flowing discharge end of a potable water supply pipeline and an open or non-pressure receiving vessel. (FCCCHR, NBS)

Air Inlet: The opening or series of openings through the body of a vacuum breaker connecting the free atmosphere with the liquid passageway of the device (ASSE 1001)

Atmospheric Air: See Section 3.5

Backflow: See Section 3.5

Backflow Connection: The point of joining of potable water piping with equipment, fixtures, or other piping that may be contaminated. (NBS)

Backflow Preventer: See Section 3.5

Backflow Preventers with Intermediate Atmospheric Vent: These devices have two independently operating check valves separated by an intermediate chamber with a means for automatically venting the chamber to the atmosphere. The check valves are force loaded to a normally closed position and the venting means is force loaded to a normally open position. These devices can operate under continuous or intermittent pressure conditions. (ASSE 1012)

4/ Sources of definitions are identified by code as follows: (See Section 7.0, references in brackets, for more detail).

ASSE 1001, 1011, 1012, 1013, 1015 [3, 4, 5, 1, 6]----Standards of the American Society of Sanitary Engineering

FCCCHR--------------------------------[2]----------Foundation for Cross Connection Control and Hydraulic Research

NBS---When used alone, the definition was generated by the authors at NBS; when used jointly, the definition was modified from one published by the other source.

NSPC----------------------------------[10]----------National Standard Plumbing Code

RP 1086-------------------------------[11]----------Hunter, Golden, and Eaton, "Cross-Connections in Plumbing Systems."

Backflow Preventers, Reduced Pressure Principle, Back Pressure: See Section 3.5

Backflow Preventers, Double Check Valve Type, Back Pressure: These devices consist of two independently acting check valves internally force loaded to a normally closed position and designed and constructed to operate under intermittent or continuous pressure conditions. (ASSE 1015)

Back Pressure: See Section 3.5

Backsiphonage: The backflow of possibly contaminated water into the potable water supply system or the potable water distribution system as a result of the pressure in the potable water system becoming unintentionally less than the atmospheric pressure in the plumbing fixtures, pools, tanks or vats that may be connected to the potable water distribution piping. (NBS)

Ball Cock: A water supply valve opened or closed by means of a float or a similar device and used to supply water to a tank. (ASSE 1001)

Ball Cock, Anti-Siphon: A ball cock that contains an anti-siphon device in the form of an approved air gap or a vacuum breaker which is an integral part of the ball cock unit and which is positioned on the discharge side of the water supply control valve. (ASSE 1001)

Check Valve Assembly: A combination of spring and weight loaded check valves with resilient discs for the intended purpose of preventing back pressure backflow in a water supply line. Assembly is usually furnished with test cocks for field testing the tightness of the check valves. Some assemblies include a vacuum breaker to admit atmospheric air downstream of the assembly. (ASSE 1013)

Contamination: See Section 3.5

Contaminants: See Section 3.5

Control Valve: See Section 3.5

Critical Installation Level: A designated operational limitation prescribing a safe height for the installed vacuum breaker above the flood-level rim of the fixture or receptacle served. In the absence of a physical mark on the device, indicating a height measurement reference point, the extreme bottom of the device shall be considered the height reference point. (ASSE 1001)

Cross Connection: Any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other either water of unknown or questionable safety or steam, gas, chemicals or other substances, whereby there may be a flow from one system to the other, the direction of flow depending on the pressure differential between the two systems. By-pass arrangements, jumper connections, removable sections, swivel or change-over devices and other temporary or permanent devices through which or because of which backflow can or may occur are considered to be cross connections. (FCCCHR)

Cross Connection, Point of: The specific point or location in a potable water distribution where a cross connection exists. (FCCCHR)

Flood Level Rim: That level from which liquid in plumbing fixtures, appliances or vats could overflow to the floor when all drain and overflow openings built into the equipment are obstructed and the rate of water supply exceeds the drainage rate. (NBS)

Guide Criteria: A technical document which serves as a guide to the compilers of standards, codes, or similar compilations to assure uniformity of format and thoroughness of subject matter. (NBS) A guide criteria document defines a methodology for systematic reproducible measurements of essential performance characteristics and the methodology for prediction of the adequacy of anticipated service performance of a material, a piece of equipment, an assemblage of components, or a functionally complete system.

Hazard: See Section 3.5

Hazard, Health: See Section 3.5

Hazard, Minimal: See Section 3.5

Health Agency: See Section 3.5

i.p.s. (iron pipe size): See Section 3.5

Piezometer: See Section 3.5

Piezometer Orifice: See Section 3.5

Potable Water: See Section 3.5

Pollution: See Section 3.5

Pressure, Absolute: Pressure measured on a scale having a zero value approximately 14.7 lb/in^2 below normal atmospheric pressure. (RP 1086)

Pressure, Atmospheric: See Section 3.5

Pressure, Differential: See Section 3.5

Pressure, Hydrostatic: See Section 3.5

Pressure, Working: See Section 3.5

Rated Flow: See Section 3.5

Service Connection: The point at or near the water main where the water purveyor delivers potable water to the consumer's water system. Usually the water purveyor loses jurisdiction and sanitary control over the water at the service connection. (FCCCHR, NBS)

Toxic: See Section 3.5

Vacuum: Any space in a water supply system from which water has been displaced by water vapor, air or other gases when the pressure in the system is less than the prevailing atmospheric pressure. It is also used to designate the pressure measured below atmosphere as a base. (usually expressed in inches of mercury)

Vacuum Breaker, Atmospheric Type: A back-siphonage prevention device which is designed to operate under pressure only when water is flowing through the system and not under static, standing conditions. Must be installed upstream of any shut-off or control valve or means. (ASSE 1011)

Vacuum Breaker, Pressure Type: A back-siphonage prevention device which can be subjected to continuous pressure, flowing, static, or both. (ASSE 1011)

Vacuum Breaker, Hose Connection Type: A backflow prevention device designed to be attached to an outlet having a hose connection thread. It may be either atmospheric or pressure type. (ASSE 1011)

Water Hammer: See Section 3.5

Water Purveyor: See Section 3.5

Water Supply Approved: See Section 3.5

7.0 REFERENCES

[1] A.S.S.E. 1013, "Performance Requirements for Reduced Pressure Principle Back Pressure Backflow Preventers," American Society of Sanitary Engineering, 228 Standard Building, Cleveland, Ohio, June 1971.

[2] Springer, E. K., "Manual of Cross-Connection Control", Foundation for Cross Connection Control and Hydraulic Research, University of Southern California, Los Angeles, California, 1974.

[3] ANSI - A112.1.1 - 1971 "Performance Requirements for Pipe-Applied Atmospheric Type Vacuum Breakers," (A.S.S.E. 1001), American Society of Sanitary Engineering, 228 Standard Building, Cleveland, Ohio.

[4] A.S.S.E. 1011, "Hose Connection Vacuum Breakers", American Society of Sanitary Engineering, 228 Standard Building, Cleveland, Ohio, June 1970.

[5] A.S.S.E. 1012, "Backflow Preventers with Intermediate Atmospheric Vent", American Society of Sanitary Engineering, 228 Standard Building, Cleveland, Ohio, May 1972.

[6] A.S.S.E. 1015, "Double Check Valve Type Back Pressure Backflow Preventers", American Society of Sanitary Engineering, 228 Standard Building, Cleveland, Ohio, May 1972.

[7] A.S.S.E. 1020, "Performance Standard for Vacuum Breakers, Antisiphon, Pressure Type," American Society of Sanitary Engineering, 228 Standard Building, Cleveland, Ohio, November 1974.

[8] Baird, J. N., Sanford, W. R. and Cristy, G. A., "Reduced Pressure Principle Backflow Preventer Evaluation and Use at Oak Ridge National Laboratory" "Health Physics" Pergamon Press 1965 Vol. 11, pp. 743-757.

[9] Sherlin, G. C. and Beausoliel, R. W., "Evaluation of Backflow Prevention Devices: A State-of-the-Art Report," National Bureau of Standards (U.S.), NBSIR 76-1070 (in review)

[10] National Standard Plumbing Code - 1975 Co-sponsored by National Association of Plumbing-Heating-Cooling Contractors and the American Society of Plumbing Engineers, (National Association of Plumbing Heating - Heating-Cooling Contractor, Washington, D.C., June, 1975)

[11] Hunter, R. B., Golden, G. E. and Eaton, H. N., "Cross-Connections in Plumbing Systems" National Bureau of Standards (U.S.) Research Paper RP 1086, Vol. 20, April 1938.

8.0 APPENDIX

8.1 Comparison of Subject Matter in ASSE 1013 with FCCCHR Section 10, Manual of Cross-Connection Control, March 1974

Manual of Cross-Connection Control Revision 5, March 1974 (Section 10.)	Excerpts or Comments from or About A.S.S.E. 1013 "Performance Requirements for Reduced Pressure Principle Back Pressure Backflow Preventers" June 1971
SPECIFICATIONS OF BACKFLOW PREVENTION DEVICES	
10.1.1 General Specifications	
10.1.1.1 Flow Characteristics and Pressure Loss Requirements	
The flow characteristics and pressure loss requirements of these devices are of prime consideration in insuring their functional operation.	Not covered by A.S.S.E. 1013
In all cases the flow channels shall be streamlined to minimize pressure loss.	1.2.2 (part) Flowways should be designed to reduce cavitation and pressure loss.
The lowest possible head loss through the backflow prevention device is necessary to deal with intermittent low main pressure and high in-plant head losses. Limits shown in columns (3) and (4) of Table 10-1 are presently commercially attainable.	Not covered by A.S.S.E. 1013
10.1.1.2 Rated Flow and Maximum Allowable Pressure Loss	
The American Water Works Association and the New England Water Works Association have adopted values for the rated flow which must be at least met by displacement or compound meters in sizes 3/4 inch to 10 inch, inclusive. Those flow rates are included in Table 10-1 for the above sizes together with those for 1/4, 3/8, 1/2, 1-1/4 and 2-1/2 inch, which have been extrapolated or interpolated.	Not covered by A.S.S.E. 1013
For each size of backflow prevention device at any flow rate up to and including the rated flow, the maximum pressure loss shall not exceed the values given in Table 10-1.	2.4 The required rated water flow and maximum allowable pressure loss shall be as shown in Table 1.
10.1.1.3 Standard Sizes	
The following standard sizes have been adopted for backflow prevention devices; 1/4, 3/8, 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 4, 6, 8, 10 inches.	1.1.1.2 SIZE - Connection pipe sizes 1/2" to 16" inclusive.
All devices designed and constructed in sizes other than those aforementioned shall be given separate consideration.	Not covered by A.S.S.E. 1013
10.1.1.4 Markings	1.6 Marking
Size, model number and serial number markings on backflow prevention devices shall be with letters or numbers at least 1/4 inch in height. All markings shall be easily read and shall be either cast in the metal or stamped on a durable nameplate permanently affixed to the assembly and shall be located either; a) on both sides of the device, or b) on a top surface of the body. In affixing a nameplate with escutcheon pin or stamping data in the metal of the device, caution shall be exercised so as not to produce an area of stress concentration. Markings shall be permanent and not easily defaced. The markings shall include those shown in Table 10-2.	1.1.1 Each device shall have the following information marked on it when it will be visible after the device has been installed. a. Name of manufacturer of trademark b. Type and model number of the device c. Maximum rated working pressure d. Devices shall be marked with the maximum water temperature for which they are designed. e. Date of manufacture or serisl number or other marking consistent with the manufacturers standard practice. f. Inlet and outlet connection pipe sizes. g. The direction of water flow through the device shall be shown. h. The marking shall be either cast, etched, stamped or engraved on the device or on a desirable metal plate securely sttached to the device.

TABLE 10-2

MARKINGS FOR BACKFLOW PREVENTION DEVICES

Name or Trademark

Type of device (i.e., reduced pressure principle or double check valve backflow prevention device, pressure vacuum breaker or acceptable abbreviation)

Size

Model Number

Direction of flow (shown by an arrow)

Unit serial number

Maximum working water pressure (MWWP)

SEC. 10 (cont.)

10.1.1.5 Hydrostatic Test - Structural and Operational

a. All devices shall be pressure tested according to their designed operating pressure for use on cold water service (maximum 110°F)*. Normal test and full hydrostatic test pressures for the 150 psi range shall be as follows: water working pressure 150 psi; full hydrostatic pressure 300 psi. All devices shall operate satisfactorily at the maximum water working pressure.

1.1.1.3 Working Pressure - Devices shall be designed for a working pressure of st least 150 psi.

1.1.1.4 Tempersture
a) Cold water devices: 33 to 110°F.
b) Hot water devices: Temps. sbove 110°F.

2.1 The device shall be subjected to a hydrostatic pressure of two (2) times the rated working pressure applied at the inlet.

b. The entire assembly shall be subjected to the hydrostatic test. Also, the maximum water working pressure shall be applied to the downstream side of all closed barriers with the opposite side open to the atmosphere with no leakage across the barrier. For each test the pressure is to be maintained for at least two minutes.

2.2 A pressure of two (2) times the rated working pressure applied to the outlet of the device with inlet and intermediate chamber pressure at atmospheric shall cause no leakage, or damage to the check valve which will sdversely affect its capability for complying with the other requirements of this standard.

c. No permanent deformation of any parts of the device shall occur under the full hydrostatic test pressure.

2.2 (same as above)

d. All diaphragms, bellows, or other barriers to the atmosphere shall be subjected to the same hydrostatic tests as are required for the body of the device.

Not covered by A.S.S.E. 1013

e. All parts of the device shall be designed to withstand, without permanent distortion, the stresses developed by the specified hydrostatic test pressures as well as the combined stresses resulting from the full specified water working pressure coincident with operation under a full, unbalanced pressure** condition. Such tests shall be from a fully opened to a fully closed position with the accompanying shock and water hammer at double the water working pressure.

Not covered by A.S.S.E. 1013

10.1.1.6 General Statement of Policy Regarding Assembled Devices

All devices which consist of independent units assembled for the purpose of preventing backflow shall comply with the material, the operational and other specifications as required for backflow prevention devices. Furthermore, all backflow prevention devices shall be delivered for installation completely assembled with all components as approved.

Not covered by A.S.S.E. 1013

10.1.2 Design Specifications

10.1.2.1 Policy Regarding Design

In the design of any backflow prevention device, prime consideration shall be given to the construction of a trouble-free unit. All materials used shall be of the best quality. The water way shall be as free as possible from obstructions and pockets which could interfere with the free flow of water. All moving parts shall be designed to operate up to the rsted flow without chatter or vibration. The moving parts shall have adequate clearance to prevent binding or galling, or to prevent the device from becoming inoperative by being thrown out of balance, by being distorted, by having one part interfere with another, or by becoming encrusted with lime, rust or scale deposits.

More detailed in statement than that in A.S.S.E. 1013, para. 1.2.2

All foundry and machine work shall be performed in accordance with the best modern practice for the class of work involved. All parts shall conform, with allowable tolerance, to the manufacturer's specifications and shall be free from injurious defects. All flanged joints shall be faced true and machined at right angles to their respective axes; while threaded joints must be concentric and accurately cut. All joints shall be watertight where subject to water pressure. All ferrous parts receiving a bronze or other alloy mounting shall be finished to fit. Such handwork as required in finishing shall produce a

* Devices for hot water are separately covered.

**Unbalanced pressure - shall include variations from zero to 150 psi wwp at intervals of no more thsn 20 psi.

neat, workmanlike, well-fitting and smoothly operating product. All replaceable parts of assemblies of the same size and model shall be interchangeable with the original parts.

The operation of the device shall not cause water hammer or be adversely affected by water hammer arising from an outside condition.

More vigorous than Para. 1.2.2

Devices intended for elevated temperatures of over 110°F shall be so designed and tested as to function satisfactorily over the specified temperature range.

10.1.2.2 Removability of Major Components from the Line

A backflow prevention device shall be designed so that each principal component (i.e., check valve if a separate body, and the relief valve) of the assembly may be removed and reinstalled individually from the line.

1.2.3 Repairs and Replacement of Parts
The internal parts of the device shall be accessible for inspection, repair or replacement.

10.1.2.3 Accessibility of Internal Parts

A backflow prevention device shall be provided with one or more openings through which the internal parts may be removed, repaired or inspected without having to remove the body of the device from the line.

1.2.3 (continued)
For sizes larger than 2 inches the design shall permit servicing without removing the devices from the line.

10.1.2.4 Interdependence of Components

In the reduced pressure principle assembly the check valves shall likewise be free of any coupling mechanical linkage. Further, the relief valve shall be mechanically independent of either check valve yet hydraulically dependent upon the pressure drop across the first check valve.

10.1.2.5 Relief Valve Port

The relief valve discharge port shall not be of a size that can be threaded for IPS or tubing either internally or externally. Further, the shape of the port shall be such that no piping or hose connection of any type can be easily made to it.

Not covered by A.S.S.E. 1013

10.1.2.6 Design of Waterway

a. Area of Waterway. Backflow prevention devices shall be so designed that the minimum waterway area normal to the direction of flow is at least equivalent to the corresponding pipe area for the size of device concerned.

b. Obstructions. The waterways of the device shall be so designed as to minimize cavitation and eliminate all cavities which could entrap foreign materials.

c. Turbulence. The turbulence within or created by the device shall not be excessive for all flow rates up to the rated flow conditions.

10.1.2.7 Clearance

a. Between guide stems and guides, valve stems and guides, hinge pins and bushings and other similar parts the clearances shall be adequate to prevent sticking or binding.

1.2.4 Valve Guide Clearance
Clearance between valve stems and associated guides, and similar moving parts should be designed to yield a low probability of malfunctioning due to corrosion and deposition of foreign matter on sliding surfaces.

b. Binding or clogging of parts might occur between the body of a valve or hinge arm, clapper, counterweight, poppet valve or other similar free-moving part. Wherever such binding or clogging of parts might occur which would prevent the device from being free to operate normally, there shall be provided minimum clearances as follows: for iron-body devices of all sizes, 1/2 inch clearance; for brass or bronze devices in sizes up through 1 inch, 1/8 inch clearance; for brass or bronze devices over 1 inch, 1/4 inch clearance.

c. The facing ring for all sizes of poppet type valves shall be supported at its outer edge for at least two-thirds of its thickness and be held in place with a clamping ring having an adequate radial bearing surface dimension. Furthermore, the facing ring must be wide enough to overhang the seat ring at least 1/16 inch on the outside. A minimum of 1/16 inch shall be provided between the inside edge of the seat ring and the facing clamping member.

d. The facing ring for all sizes of swing type valves shall be protected at its outer edge for at least two-thirds of its thickness and be held in place with a clamping ring having an adequate bearing surface. Furthermore, the facing ring must be wide enough to overhang the seat ring at least 1/8 inch on sizes up to 2 inches and 1/4 inch on sizes 2 inch and larger. A minimum of 1/16 inch shall be provided between the inside edge of the seat ring and the facing ring clamp.

e. All bushings shall project inside the body of the device as follows:

1/8 inch for sizes up through 1 inch
1/4 inch for all sizes over 1 inch

10.1.2.8 Body and Bonnet

When body and bonnet are bolted together, the bolts shall be of such design that the maximum stress at the root diameter shall not exceed a calculated 7,500 psi, based on the rated working water pressure.

Not covered by A.S.S.E. 1013

10.1.2.9 Tapping and Threading

Valve bodies shall be provided with an adequate boss at each location where a tapped hole is required. The valve bodies shall be threaded or flanged in accordance with the U S A S I standards for the standard pipe sizes mentioned in Article 10.1.1.3.

1.2.7 Pipe Threads

1.2.7.1 Taper pipe threads except dryseal shall be in compliance with Standard ANSI B 2.1 - 1968

1.2.7.2 Dryseal shall comply with Standard ANSI B 2.2 - 1968

1.2.8 Pipe flanges shall conform to USA B 16.24 - 1962 for bronze flanges and USA B 16.1 - 1967 for cast iron flanges.

1.3.2 Threaded and flanged connections shall conform to subsections 1.2.7 and 1.2.8

10.1.2.10 Test Cocks

Double check valve and reduced pressure principle backflow prevention assemblies shall be equipped with brass or bronze test cocks located as follows:

a. On the upstream side of the No. 1 shut-off valve

b. Between the No. 1 shut-off valve and the No. 1 check valve

c. Between the check valves

c. Between the No. 2 check valve and the No. 2 shut-off valve.

(See Fig. 10-1 and Fig. 10-2.)

The sizes of these test cocks shall be as given in Table 10-3. Test cocks shall have IPS female ends on the discharge end.

Further, the test cocks shall be of a sturdy design drip-tight, and with an operating stem designed to clearly show whether the test cock is open or closed.

TABLE 10-3

SIZES OF TEST COCKS

Size of Device (inches)	Minimum Size of Standard Test Cock (IPS) (inches)
1 and below	1/8
1-1/4 to 2, incl.	1/4
2-1/2 to 4, incl.	1/2
6 and larger	3/4

1.2.10 Test Cocks shall be provided in the device upstream of the inlet check valve, the downstream end of the outlet check valve and in the intermediate chember. Pipe size of the tappings for test cocks shall be as in Table 1. See also 1.5.1

TABLE 1

Size of Device	Min. Size of Tapping, IPS
1" and smaller	1/8"
1-1/4" to 2" incl.	1/4"
2-1/2" to 4" incl.	1/2"
6" and larger	3/4"

1.2.11 Test cocks shall be of bronze ASTM B145-52-Alloy 5a, or of a non-ferrous material at least equal in strength and corrosion resistance. They shall have a female pipe thread at the outlet and be installed on the device by either a male thread on the inlet of the cock or by a corrosion resisting nipple.

10.1.2.11 Control Piping and Diaphragms

All control piping or passageways shall be of corrosion-resistant material and in sizes sufficiently large to prevent clogging. Also, the pipe or passageways shall be located in a manner as to prevent entrapment of foreign materials or air. Furthermore, all external control piping shall be placed in such a manner that it does not present a "Desirable nuisance" when the device is in unprotected areas.

1.3.6 Piping and passageway areas should be of a size to reduce the probability of clogging and entrapment of foreign materials.

1.3.8 Cavities in flow passages which could entrap foreign materials should be avoided as far as possible and practical.

When diaphragms or bellows are used as barriers in control piping which by-passes one or more check valves in the backflow prevention assembly; such a diaphragm or bellows shall be installed in such a manner that its failure shall produce visible evidence of such a failure.

1.2.6 Diaphragms or bellows used as barriers in control piping which by-passes one or more check valves shall be installed in a manner which, in case of failure, will produce visible evidence of failure.

10.1.2.12 Air Release

Provision shall be made for bleeding trapped air from the highest point of the device when the normal flow of water will not displace it.

1.3.7 Provision shall be made for bleeding trapped air from the device when its accumulation would adversely affect its performance.

10.1.2.13 Valve Seats

All iron-bodied devices shall be fitted with renewable valve seats which shall be provided with means of insertion and removal.

10.1.2.14 Alignment

The clapper disc, rubber facing ring, clamping ring and the securing bolt or stud shall be concentric to an axis which is normal to the face of the rubber ring. A means must be provided to prevent clamping the rubber facing ring so tight as to warp its face.

Provision shall be made to prevent the clapper from tipping and catching under the seat rung or any faulty action which would prevent true alignment. When clappers, check or poppet valves or other barriers are in a wide open position they must bear on a definite stop or surface of contact. The stops shall be so constructed and located that they will provide a firm bearing so that the action of the water will not tend to twist or bend the valve parts. All working parts shall be constructed and supported in such a manner as to preclude distortion or misalignment.

10.1.2.15 Chatter

All moving parts shall be designed to operate up to the rated flow condition in a positive manner without chatter.

10.1.2.16 Material Selection

When relative motion is to be allowed between mating parts the materials shall be sufficiently different so that there will be no scuffing or galling.

10.1.3 Material Specifications

10.1.3.1 Statement of Policy

Not covered by A.S.S.E. 1013

The following material specifications and current ASTM (American Society for Testing Materials) and/or USASI (USA Standards Institute) designations shall be adhered to at all times except where a manufacturer desires to use an equivalent or better material. In such cases the substitute specifications shall be submitted for approval. In the subsequent list of materials no attempt has been made to bar the use of alloys, rubbers, plastics, or other materials which may be adaptable and which will give at least the equivalent trouble free service.

10.1.3.2	Dissimilsr Metals In the construction of bsckflow prevention devices a minimum of dissililar metals shall be used. In all cases where it is impossible to use similsr metals, steps shall be taken, insofar as it is practicable, to prevent the formation of galvanic electrolytic couples. To this end, when two dissililar metals must come close to each other, the metals chosen shall be as nearly as possibly electrolytically similar and shall be insulated whenever possible.	1.4.1	Dissimilsr Metals Diversity of metsls in the construction of devices used in water pipe lines is conducive to galvanic corrosion. Where different materials sre used, this sction csn be substantially reduced by selecting materials which are close to each other in the electromotive scale. The use of insulstion may also be employed. Both expedients should be employed to the fullest practical extent.
10.1.3.3	Corrosion Ferrous metals contained in backflow prevention devices shall be galvanized or otherwise protected to resist corrosion.	1.4.3	Ferrous cast parts in contact with the water flowing through the device shall be protected against corrosion by hot dip galvanizing, ASTM A153, Class A or B, or by other proven methods.
10.1.3.4	Body and Cover, Spools and Spacers Material to be used in construction of the above parts of the device shall be either valve bronze which conforms to ASTM Designation: B 61-63; or gray iron which conforms to ASTM Designation: A 126-66, Class B; or Schedule 40 pipe and flanges - either galvanized or otherwise suitably protected against corrosion.		
10.1.3.5	Seat Rings The seat rings shall be constructed of valve bronze which conforms to ASTM Designation: B 61-63; or stainless steel which conforms to ASTM Designation A 276, Type 304.		
10.1.3.6	Clapper The clapper, poppet or similar check shall be constructed of valve bronze which conforms to ASTM Designation: B 61-63.		
10.1.3.7	Clapper, Poppet or Relief Valve Fscing Ring a. The clapper or poppet facing ring shall be composed of molded natural rubber or a synthetic elastomer of even thickness, smooth-faced and with a Shore hardness of between 35 snd 45. b. The relief valve facing ring shall be composed of molded natural rubber or a synthetic elastomer of even thickness, smooth-faced and with a Shore hardness of between 60 snd 70. c. For both facing rings, a) and b) above, the dimemsional stability must be good with very little water absorption and essentially no continued polymerization. Good quality control is of paramount importance.	1.4.6	Diaphragms, valve discs, seat facings or other flexible non-metsllic parts shall be designed for continuous exposure to water at the maximum rated operating temperature of the device without change in physical chsracteristics which would prevent full compliance with all requirements of the standard.
10.1.3.8	Swing Arm The swing arm shall be made of valve bronze which conforms to ASTM Designation: B 61-63.		
10.1.3.9	Swing Pin and Guide Stem The swing pin or guide stem shall be made either of phosphor bronze which conforms to ASTM Designation B 139-66, Grade A, C, or D; or of corrosion-resistant steel which conforms to ASTM Desingation: A 276-67, Type 304.	1.4.4	Internal non-cast parts shall be of material having a corrosion resistance at least equal to a non-ferrous alloy of not less than 85% copper.
10.1.3.10	Bushings Bushings shall be made of high-leaded tin-bronze which conforms to ASTM Designation: B 144-52 (1961), Alloy No. 3A or 3D.	1.4.4	(above)
10.1.3.11	Counterbalance The counterbalance shall be either a bronze shell with lead; or, a white metal bearing alloy which conforms to ASTM Designation: B 23-66, Grade No. 19.	1.4.4	(above)

10.1.3.12 Springs

All springs shall be made of either corrosion-resisting steel which conforms to ASTM Designation: A 313-67; or of phosphor bronze which conforms to ASTM Designation: B159-66; or equal.

1.4.5 Springs in contact with the water flowing through the device shall have a corrosion resistance at least equal to chrome nickel steel, Series 300.

10.1.3.13 Diaphragms

The diaphragm material shall be a cotton, rayon or nylon cloth laminated between and made an integral part of a natural rubber or synthetic elastomer with workmanship equivalent to that shown in "Federal Specifications for Packing: Rubber, Cloth and Insertions HH P-151B."

1.4.6 Diaphragms, valve discs, seat facings or other flexible non-metallic parts shall be designed for continuous exposure to water at the maximum rated operating temperature of the device without change in physical characteristics which would prevent full compliance with all requirements of the standard.

10.1.3.14 Protective Coatings

All cast-iron bodies and parts shall be zinc coated (hot-dipped) in conformance with ASTM Designation: A 153-67, Class A or B, or, with an approved polymerized plastic. The use of synthetic protective coatings on cast-iron bodies and parts shall be subject to the individual approval not only of the specific use but of the coating and process of application.

1.4.3 Ferrous cast parts in contact with the water flowing through the device shall be protected against corrosion by hot dip galvanizing, ASTM A153, Class A or B, or by other proven methods.

10.1.3.15 Studs, Bolts and Cap Screws

Such parts shall be made of naval brass rod which conforms to ASTM Designation: B 21-66a, Alloy No. 482 or 485; or corrosion-resistant steel which conforms to ASTM Designation: A 276-67, Type 304.

1.4.4 Internal non-cast parts shall be of material having a corrosion resistance at least equal to a non-ferrous alloy of not less than 85% copper.

10.1.3.16 Control Piping

Control piping shall be made of copper or equally corrosion-resistant material.

1.3.6 (part) Control piping shall have a corrosion resistance at least equal to red brass pipe ASTM B 302-1968.

10.1.3.17 Test Cocks

Test cocks shall be made of high-leaded tin-bronze which conforms to ASTM Designation: B 144-52, Alloy No. 3A, 3D or 3E.

1.2.11 Test cocks shall be of bronze ASTM B145-52-Alloy 5a, or of a non-ferrous material at least equal in strength and corrosion resistance. They shall have a female pipe thread at the outlet and be installed on the device by either a male thread on the inlet of the cock or by a corrosion resisting nipple.

10.1.3.18 Shut-off Valves

Shut-off valves shall be tightly closing so as not to interfere with the testing of the devices.

Not covered by ASSE 1013 except indirectly in 1.5.1, "These instructions shall show a shut-off valve installed both upstream and downstream of the device to enable field testing."

10.2 Part II - EVALUATION OF DESIGN AND PERFORMANCE

10.2.1 General

The specifications set forth in this Manual supersede the specifications of previous editions of this Manual as well as those of Paper No. 5 and USCEC Report No. 48-101.

Not appropriate to ASSE 1013

10.2.1.1 Drawing and Specifications

A full set of working drawings and specifications of all materials shall be furnished with each size and model of device that is submitted for evaluation.

1.2.1 Drawings
Assembly drawings and other data which are needed to enable a testing agency to determine compliance with this standard, and installation drawings, shall accompany devices when submitted for examination and performance tests under this standard.

10.2.1.2 Units Required for Evaluation

a. Laboratory Evaluation. One or more units, selected at random from the manufacturer's stock, of each size and model shall undergo a complete laboratory evaluation of its design and operating characteristics including hydrostatic tests under the supervision of the Foundation for Cross-Connection Control and Hydraulic Research or an approved testing laboratory.

1.7 Devices Required for Testing

The manufacturer shall submit for testing, one (1) of each type and size device for which tests are requested. These devices shall be of production quality.

b. Field Evaluation. Upon completion of a satisfactory laboratory evaluation, three (3) units, selected at random from the manufacturer's stock, of each size and model shall undergo a satisfactory twelve (12) month field performance under the supervision of the Foundation for Cross-Connection Control and Hydraulic Research or an approved testing laboratory.

Not covered by ASSE 1013 except as in 1.5.3, "Manufacturer's recommendations for field testing shall be furnished upon request.

10.2.1.3 Selection of Field Locations — Not covered by ASSE 1013.

The Foundation for Cross-Connection Control and Hydraulic Research or an approved testing laboratory may reject any field evaluation site submitted by the manufacturer.

10.2.1.4 Period for Field Evaluation — Not covered by ASSE 1013.

All three units undergoing field evaluation for each size and model of device (see Art. 10.2.3.2) shall give trouble-free operation for a minimum period of twelve (12) months in conformance with the Field Evaluation Specifications set forth herein for each type of device. Before a specific size and model of device may be released from the Field Evaluation it must be inspected to determine that all of the working parts continue to conform to the design specifications furnished by the manufacturer.

10.2.1.5 Approval — Not covered by ASSE 1013

Upon the completion of a satisfactory laboratory and field evaluation, the Foundation for Cross-Connection Control and Hydraulic Research or an approved testing laboratory will grant a "Certificate of Approval" for the specific size and model evaluated under these specifications. This certificate will be valid for a period of three (3) years - unless rescinded for cause before that time.

10.2.1.6 Renewal of Certificate of Approval — Not covered by ASSE 1013

Continuing verfication of compliance with these specifications and field performance shall be accomplished at a minimum three (3) year period to the satisfaction of the original approving authority. Past performance of the device under field operating conditions shall be considered before the re-issuing of a Certificate of Approval. Failure to meet this requirement shall result in the automatic withdrawal of the approval for that size and model of device.

10.2.1.7 Change of Design, Materials or Operation — Not covered by ASSE 1013

The original approving authority shall be notified in writing of any change in design, materials or operation of an approved device which is in the field or which is offered for sale. The original approving authority, at its own discretion, may or may not require another laboratory and/or field evaluation. Failure to notify the original approving authority of any changes of design, materials or operation is cause for the rescinding of the Certificate of Approval for the size and model of device involved.

10.2.1.8 Prior Approval — Not covered by ASSE 1013

a. On the publication date of this Manual all sizes and models of assemblies having been previously approved will henceforth be designated by reference to the specifications under which each device was certified. The re-issued certificate will show compliance with either Paper No. 5, USCEC Report 48-101, or Editions 1, 2, 3 or 4 of this Manual.

b. Backflow prevention assemblies approved under the above paragraph (10.2.1.8a) will be approved for installation as set forth herein.

c. Continuing verification of compliance with the specifications under which a size and model of device was orginally approved shall be accomplished at least once each three (3) years from the date of issuance of the new certificate to the satisfaction of the original approving authority. Past performance of the device under field operating conditions shall be considered before the re-issuing of a Certificate of Approval. Failure to meet this requirement shall result in the automatic withdrawal of the approval for that size and model of device.

d. A Certificate of Full Approval or Approval granted under conditions of prior approval (10.2.1.8a) or a Certificate of Approval granted under the conditions of this 5th Edition of the Manual may be rescinded at any time by the Foundation or an approved testing laboratory for cause.

10.2.1.9 Notification of Failure

If, in the judgment of the Foundation or an approved testing laboratory, a device fails to meet the specifications set forth in this Manual, the following offices, having cognizance of the field test location, in addition to the manufacturer shall be immediately notified:

a) the local health agency
b) the local plumbing authority
c) the local water purveyor.

10.2.2 Design, Operations and Evaluation Specifications for Reduced Pressure Principle Backflow Prevention Devices

10.2.2.1 Design and Operational specifications

a. This device shall include two approved, independently operating check valves with an automatically operating, mechanically independent, hydraulically dependent pressure differential relief valve located between the two check valves. The unit shall include a tightly closing shut-off valve on each end of the device and each device shall be fitted with four properly located test cocks. (See Fig. 10-1 for diagrammatic layout.)	1.1.1.1	Class of Devices This standard applies to only the type of backflow prevention devices identified as "Reduced Pressure Principle Backflow Preventers." These devices consist of two independently acting check valves, internally force loaded to a normally closed position, and separated by an intermediate chamber (or zone) in which there is an automatic relief means for venting to atmosphere, internally force loaded to a normally open position. These devices are designed to operate under continuous pressure conditions.
During normal flow and at the cessation of normal flow, the pressure in the "zone", i.e., the "zone" between these two check valves, shall be at least 2 psi less than the upstream (or supply) pressure.	2.5	When operating under either static or flow conditions, the intermediate zone pressure shall be at least 2 psi lower than the pressure in the inlet of the device.
b. With no flow from the upstream side when the pressure on the supply side drops to 2 psi, the pressure within the "zone" shall be atmospheric. When the pressure on the upstream side drops below 2 psi, the relief valve shall open further and shall be fully open when the upstream pressure reaches atmospheric or goes below atmospheric.	2.6	Where there is a static operating condition and the supply pressure falls off to 2 psi, the pressure in the intermediate chamber, or zone, shall become atmospheric.
c. Under a backflow conditions, when the upstream pressure is 2 psi or more, the relief valve shall discharge from the "zone" to atmosphere the quantities of backflowing water given in Table 10-4, and the pressure in the "zone" shall be at least 1/2 psi below the upstream pressure.	2.7(a)	Where there is backflow and the supply pressure is 2 psi or greater, the relief valve shall discharge water from the zone to atmosphere at the rate of discharge corresponding to the data shown in Table 3, and the pressure in the zone shall be at least 0.5 psi below supply pressure.
d. The downstream or second check valve shall be internally loaded and shall at all times be drip tight in the normal direction of flow with the inlet pressure at 1 psi and the outlet under atmospheric pressure.	2.3	The outlet check valve shall be drip tight when the intermediate pressure is 1 psi and the outlet pressure is atmospheric.
e. When the upstream pressure is less than 2 psi, the pressure differential relief valve shall discharge water from the "zone" to atmosphere with the rate of discharge corresponding to the data shown in Table 10-4; and, the pressure in the "zone" shall not exceed 1-1/2 psi.	2.7(b)	When there is backflow and the supply pressure is less than 2 psi, the relief valve shall discharge water from the zone to atmosphere with the rate of discharge corresponding to the data shown in Table 3 and the pressure in the zone shall not exceed 1.5 psi.
f. The differential pressure relief valve shall open and close positively and quietly. Further, it shall not spit water under fluctuating line conditions when the upstream pressure is 3.0 psi or more above the differential pressure required to open the relief valve.	2.8 2.9	The pressure relief or atmospheric vent valve shall not start to open until (when) the pressure in the intermediate chamber is at least 2 psi lower than the pressure in the inlet of the device. It shall open and close positively. The relief valve shall not discharge water under supply pressure fluctuation of ± 1-1/2 psi maximum variation.
g. The differential pressure relief valve shall be located so that the valve seat and discharge port are below the lowest portion of the #1 check valve so as to preclude the back-siphonage of any industrial water.		Not covered by A.S.S.E. 1013

TABLE 10-4

MINIMUM FLOW RATES AND SIZE OF MINIMUM AREA
OF PRESSURE DIFFERENTIAL RELIEF VALVE OPENING

Size of Device (inches)	Minimum Flow Rate Past Relief Valve (gpm)	Minimum Diameter of Relief Valve Porting (IPS) (inches)
1/2 and 5/8	3	3/8
3/4 and 1	5	1/2
1-1/4 and 1-1/2	10	3/4
2	20	1
2-1/2	20	1
3	30	1-1/4
4	40	1-1/2
6	40	1-1/2
8	60	2
10	60	2
12	75	2-1/2
14	90	3
16	100	3

10.2.2.2 Laboratory Evaluation

Devices will be inspected and evaluated as follows:

a. Conformance to the general, design and material requirements outlined in Part I of this Section.

b. Conformance to the operational requirements outlined in Part II of this Section.

c. Pressure loss characteristics for flow rates up to the rated conditions.

d. Conformance to the working drawings and materials specifications.

e. Hydrostatic tests - the test assembly shall be isolated on a test stand with the shut-off valves closed and subjected to the conditions of Section 10.1.1.5

f. Tolerance to sand, scale and other interfering materials.

g. Ease of operation, inspection, test and repair.

8.2 Units of Measure and S. I. Conversion Factors

In NBS Document LC 1056, revised August 1975, guidelines were established to reaffirm and strengthen the commitment of NBS to the greatest practicable use of the International System of Units (S.I.) in all of its publications and also in all of its dealings with the science and engineering communities and with the public. In this report the measurements are those of the U. S. Customary units as they appear in the referenced standards, in order that the readers may give full attention to the organization and compilation of the criteria for backflow preventers. Notwithstanding the immediate objectives of this report, subsequent actions leading to the updating of backflow preventer standards should establish the metric system to the fullest extent possible.

The following conversion factors are appropriate for the units of measure that appear in this report:

Length —
- 1 inch (in.) = 0.0254 meter (m)
- 1 foot (ft.) = 0.3048 meter (m)

Mass —
- 1 pound-mass (lbm) = .4535924 kilogram

Temperature —
- 1 Degree Fahrenheit (°F) = $(1.8)^{-1}$ kelvin (K) or (°K)
- Temperature Fahrenheit (°F) = (459.67 + temp. °F)/1.8 kelvins (K)

Time —
- 1 hour (h) = 60 minutes (min) = 3600 seconds (s)

Velocity —
- 1 foot per second (fps) = 0.3048 meter per second (m/s)

Force —
- 1 pound-force (lbf) = 4.448222 newtons (N)

Pressure —
- 1 pound-force per square inch (psi) = 6894.757 pascals (Pa)
6.894757 kilopascals (kPa)
- 1 inch of water column at 60°F = 248.84 pascals (Pa)

Volume —
- 1 U. S. liquid gallon (gal) = 0.003785412 meter^3 (m^3)
= 3.785412 liters (l)

Flow Rate —
- 1 U. S. gallon per minute (gpm) = 0.0000630902 meters^3/second
= 63.0902 centimeters^3/second (cm^3/s)
= 0.0630902 liters/second (l/s)

NBS-114A (REV. 7-73)

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA SHEET**	1. PUBLICATION OR REPORT NO. NBSIR 76-1020	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

GUIDE CRITERIA FOR LABORATORY EVALUATION OF BACKFLOW PREVENTION DEVICES FOR PROTECTION OF POTABLE WATER SUPPLIES

5. Publication Date
March 1976

6. Performing Organization Code

7. AUTHOR(S)
Grover C. Sherlin, Robert W. Beausoliel, Lawrence S. Galowin

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

10. Project/Task/Work Unit No.
462.4190

11. Contract/Grant No.
EPA - IAG-0170 (D) A

12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)*
Environmental Protection Agency
Water Supply Division
Washington, D.C. 20460

13. Type of Report & Period Covered
Final Report

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report describes laboratory evaluation procedures which could be required for the approval of backflow prevention devices used to protect potable water supplies against contamination. Performance-based requirements, criteria, and general evaluation considerations that administrative authorities should require for approval of devices are presented. Recommendations for the development of tracer tests are submitted for further consideration. This document results from an investigation undertaken for the Environmental Protection Agency (EPA).

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Backflow; backflow prevention devices; back pressure; backsiphonage; guide criteria; potable water protection; plumbing guide criteria

18. AVAILABILITY

[X] Unlimited

[ ] For Official Distribution. Do Not Release to NTIS

[ ] Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13

[ ] Order From National Technical Information Service (NTIS) Springfield, Virginia 22151

19. SECURITY CLASS (THIS REPORT)
UNCLASSIFIED

20. SECURITY CLASS (THIS PAGE)
UNCLASSIFIED

21. NO. OF PAGES
40

22. Price

USCOMM-DC 29042-P74