METRIC/INCH-POUND

KSC-STD-Z-0013
Revision A

POTABLE WATER CROSS-CONNECTION CONTROL DESIGN FOR FACILITIES,

STANDARD FOR

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April 1, 2022

Engineering Directorate

National Aeronautics and
Space Administration

John F. Kennedy Space Center

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KSC-STD-Z-
Revision A

POTABLE WATER CROSS-CONNECTION CONTROL DESIGN FOR FACILITIES,

STANDARD FOR

April 1,

JOHN F. KENNEDY SPACE CENTER, NASA

RECORD OF REVISIONS/CHANGES

REV LTR	CHG NO.	DESCRIPTION	DATE
		Basic Issue	May 5, 2012
A		Updated document format. Tables and Figures moved to Appendices. References to KSC-STD-F-0004C updated to direct reader to latest revision. Added definition for “black pipe”. Revised reference to “Foamite” to indicate more general “foaming fire suppression systems”. "Lawn Sprinkler" and double asterisk (**) footnote revised to separate entries for "Irrigation Systems" and "Irrigation Systems with Chemical Feed" in Table 1. Figure for "Pressure Vacuum Breaker Assembly Installation" replaced with updated version. Figure for "Atmospheric Vacuum Breaker Assembly Installation" replaced with updated version. Old Figure for "Typical Backflow Preventer Installation (DC or RP)" replaced with new Figure "Double Check Valve Assembly Installation (2" and Smaller)" and Figure "Reduced Pressure Backflow Preventer Installation (2-1/2” and above)". Figure numbering revised.	April 1, 2022

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FIGURES

TABLES

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ASSE	American Society of Sanitary Engineering
AVB	Atmospheric Vacuum Breaker
AWWA	American Water Works Association
BFP	Backflow Preventer
DC	Double Check
FM	Factory Mutual Engineering Division
gpm	Gallons per minute
in	Inch
IPS	Iron Pipe Size
KSC	Kennedy Space Center
min	Minimum
NASA	National Aeronautics and Space Administration
NFPA	National Fire Protection Association
psi	Pounds per square inch
PVB	Pressure Vacuum Breaker
RP	Reduced Pressure
UL	Underwriters Laboratories, Inc.

1. SCOPE

1.1 Purpose

This document establishes cross-connection control standards to be used in the design of new facilities and the modification of existing facilities under the design jurisdiction of John F. Kennedy Space Center (KSC). Cross-connection control is necessary to protect potable water supplies from contamination.

1.2 General

The requirements established by this standard are based on existing codes and standards. Reference to Table 1 in Appendix A can be made for guidance in selecting the correct backflow prevention system.

2. APPLICABLE DOCUMENTS

The following documents provide the technical basis for this standard and form a part of this standard to the extent referenced herein. Only the latest revision of those referenced documents should be used.

AF Manual 85-21	Operation and Maintenance of Cross-connection Control and Backflow Prevention Systems
ASSE No. 1001	Performance Requirements for Pipe Applied Atmospheric Type Vacuum Breakers
ASSE No. 1011	Performance Requirements for Hose Connection Vacuum Breakers
ASSE No. 1013	Performance Requirements for Reduced Pressure Principle Backflow Preventers
ASSE No. 1015	Performance Requirements for Double Detector Check Valve Type Pressure Backflow Preventers
ASSE No. 1020	Performance Requirements for Vacuum Breakers Anti-Siphon, Pressure Type
AWWA C506	Backflow Prevention Devices – Reduced Pressure Principle and Double Check Valve Types
AWWA 1114	Backflow Prevention and Cross-connection Control

KSC-STD-F-0004	Fire Protection Design for Facilities
Manual of Cross Connection Control	
National Fire Codes	
PHS-957	Cross Connection Control Manual
Southern Building Code	

3. DEFINITIONS

For the purpose of this document, the following definitions shall apply.

air gap separation: The unobstructed vertical distance through the free atmosphere, between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture or other device to the flood level rim of the receptacle.

backflow: A reversal of normal flow direction in a potable water system.

backflow preventer: A device or means to prevent backflow.

backpressure: A positive pressure placed on any downstream component of a system relative to any upstream component.

backsiphonage: Backflow resulting from negative pressure in the distributing pipe of a water system.

black pipe: Refers to black steel pipe, which is bare steel pipe with no coating or galvanization, commonly used in stagnant systems where the impact of corrosion is minimized, such as fire sprinkler systems.

contamination: Loss of water potability due to the presence of environmental chemicals, radioactive elements, bacteria or organisms, the by-product of the growth of bacteria or organisms or waste in the water.

critical water supplies: Essential water supplies, potable or fire suppression, where a system outage is undesirable.

cross-connection: A connection or arrangement of piping or appurtenances through which a backflow could occur.

double check valve backflow preventer: An arrangement of two single independently acting internally force loaded check valves.

drain: Any pipe that carries wastewater or water bearing waste in a building drainage system.

external protection: A backflow preventer installed on a water service supply line to a building.

flood level rim: The edge of the receptacle or lowest level from which water overflows.

internal protection: A backflow preventer installed on equipment water service line within a building.

outlet: The open end of a water supply pipe from which the water is discharged into the plumbing fixture.

plumbing fixture: An installed device supplied with water or that receives or discharges water or liquid borne wastes.

potable water: Water from any source that has been investigated by the health jurisdiction and that has been approved for human consumption.

reduced pressure principle backflow preventer: An arrangement of internally force loaded check valves and an automatically opening differential pressure relief valve, designed to prevent backflow.

vacuum: Any pressure less than that exerted by the ambient atmosphere.

4. GENERAL REQUIREMENTS

4.1 Application of Devices

Backflow prevention devices shall be incorporated into the design of new facilities and systems. Table 1 in Appendix A lists cross-connections and the recommended approach to backflow prevention for each. When more than one device is specified for a given situation, the type of device selected will depend on the potential severity of the contamination.

4.1.1 Plumbing Fixtures

Plumbing fixtures shall be designed to incorporate an air gap as delineated in Section 4.4 and certain fixtures (as called out in Table 2 in Appendix B) shall also include a vacuum breaker.

4.1.2 Water Supply for Fire Systems

The design of fire extinguishing systems at KSC shall conform to the KSC standard "Fire Protection Design for Facilities", KSC-STD-F-0004. System components shall be UL listed or FM approved. Cross-connections may occur in fire protection systems (see Table 2 in Appendix B) where fire department hose hook-up and/or where black pipe is used. Double check valve assemblies are required for these systems. When chemicals such as foaming fire suppression systems are used in these systems, reduced pressure principle backflow prevention assemblies are necessary for extra protection. Where reduced pressure backflow prevention assemblies are

used on fire protection systems, the assembly will be hydraulically sized so as not to reduce the operating pressure of the fire protection system below its original designed operating pressure.

A parallel installation of backflow preventers is required on all fire protection systems which are connected to potable water supplies. This allows uninterrupted flow of the unit during testing and maintenance. The size of each of the two backflow preventers shall be based on both units operating. Where backflow preventers are used on fire protection systems, they will be hydraulically sized so as not to affect the designed flow and pressure requirements for the fire protection system.

4.2 Test Cocks.

Test cocks shall be installed at the following locations on all Reduced Pressure (RP) and Double Check (DC) backflow prevention devices (see Figures 1 and 2 in Appendix C):

- On the supply (inlet) side of the upstream shut-off valve.
- Between the supply shut-off valve and the first check valve.
- Between the check valves.
- Between the second check valve and the shut-off valve on the outlet side of the device.

A Pressure Vacuum Breaker (PVB) shall have two test cocks; one at the device inlet and one on the vacuum chamber (see Figure 3 in Appendix C).

4.3 Assembly Specifications

The following backflow prevention assemblies shall conform to the proper ASSE Standard and shall be approved by the Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California. Assemblies shall be delivered for installation completely assembled from the original manufacturer with all components approved.

4.3.1 Reduced Pressure Principle (RP) Backflow Prevention Assemblies

The RP device shall be tested and certified according to ASSE Standard No. 1013 and AWWA Standard No. C506. This device shall include two approved, independently operating, internally force loaded check valves with an automatically operating, mechanically independent, and hydraulically dependent pressure differential relief valve located between the two check valves. The unit shall include a resilient seated, full ported shut-off valve on each end of the device and each device shall be fitted with four properly located test cocks. (See Figure 1 in Appendix C for diagrammatic layout).

4.3.2 Double Check Valve (DC or DCV) Assemblies

The DC shall be tested and certified according to ASSE Standard No. 1015 and AWWA

Standard No. C506. This assembly shall include two independently acting, internally force loaded check valves mounted between two resilient seated, full ported shut-off valves, and four test cocks. (See Figure 2 in Appendix C for diagrammatic layout.)

4.3.3 Pressure Type Vacuum Breaker (PVB) Assemblies

The PVB shall be tested and certified according to ASSE Standard No. 1020. This assembly shall include an independently-operating, internally-loaded check valve and inlet valve located on the discharge side of check valve, and an air opening to atmosphere on the discharge side of the check valve between two resilient seated, full ported shut-off valves, and shall include two teat cocks (see Figure 3 in Appendix C).

4.3.4 Atmospheric Type Vacuum Breaker (AVB) Assemblies

This device shall be tested and certified according to ASSE Standard No. 1001. This device shall include a poppet to seal the air inlet when the unit is pressurized. The poppet drops, permitting air to travel through the piping when back-siphoning occurs. (See Figure 4 in Appendix C for diagrammatic layout).

4.3.5 Hose Connection Vacuum Breaker Assemblies

This device shall be tested and certified according to ASSE Standard No. 1011. When supply pressure through the device is atmospheric or below, a check valve closes and an atmospheric vent opens.

4.4 Design for Maintenance / Testing

To ensure adequate maintainability, the following design and installation guidelines have been established.
The approved assembly shall have resilient seated full-ported shut off valves. Test cocks shall be installed as indicated in Section 4.2.

Assemblies shall be installed according to manufacturer’s instructions. Assemblies shall be installed in an accessible location, with ample clearance to aid in testing and maintaining the device.

Assemblies installed inside facilities will be placed 12 inches to 36 inches above the finished floor.

Discharge from reduced pressure principle assembly relief valves shall not be into the sanitary collection system.

The minimum clearance above floors or grade is needed to ensure an air gap between the relief valve and any water that might puddle beneath the assembly. The maximum height is needed so that the device can be easily maintained and tested.

4.4.1 Reduced Pressure Principle (RP)

Figure 6 in Appendix C shows the proper installation of an RP assembly on a building service connection. The RP assembly can also be used for internal protection.

4.4.2 Double Check Valve (DC or DCV)

Figure 5 in Appendix C reflects a typical installation of a double check valve assembly on a service connection. This assembly can also be used for internal protection. Minimum and maximum distances are the same as that for the RP assembly.

4.4.3 Pressure Vacuum Breaker (PVB)

The pressure vacuum breaker assembly shall not be installed where there can be backpressure; only where there can be backsiphonage. Shut-off valves may be installed downstream of the PVB. The pressure vacuum breaker assembly shall be installed at least 12 inches above the highest outlet or, if it is feeding an open tank, at least 12 inches above the highest overflow rim of the tank. Figure 7 in Appendix C reflects a typical PVB installation on a lawn sprinkler system.

4.4.4 Atmospheric Vacuum Breaker (AVB)

The atmospheric vacuum breaker assembly shall not be installed where there can be back-pressure, only where there is backsiphonage. No shut-off valves shall be installed downstream of the AVB. The AVB assembly shall be installed at least 12 inches above the highest outlet or the topmost overflow rim of a non-pressure tank. Figure 8 in Appendix C reflects a typical AVB installation on a sprinkler system.

4.4.5 Air Gap

An air gap shown in Figure 9 in Appendix C is the physical separation of a potable water system supply line and the flood rim of an open receiving tank. Air gap separation shall be at least double the diameter of the supply pipe, measured vertically above the top rim of the vessel and in no case less than 1 inch.

4.4.6 Parallel Installation

Critical water supplies shall have parallel installation of the proper approved backflow prevention assembly. Figure 10 in Appendix C reflects a typical parallel installation. This avoids interruption to the water service when maintenance or testing is required. This type installation also provides an equal or higher flow capacity than provided by one backflow preventer.

4.5 Design Parameters

4.5.1 Nominal Size

The size of a backflow preventer (see Table 2 in Appendix B) shall be identified by the size of the standard shut-off valves provided as part of the assembly and attached at each end of the assembly.

4.5.2 Rated Flow and Allowable Pressure Loss

The maximum allowable pressure loss at any rate of flow, from zero, up to and including the maximum rated flow for the indicated size, shall not exceed the values shown on Table 2 in Appendix B.

4.6 Freeze Protection

Provisions shall be made to protect devices from freeze damage. Assemblies installed outdoors shall be protected from freeze damage by installing a thermostatic freeze protection valve directly downstream of the BFP. Figures 11 and 12 in Appendix C show typical installations. Another acceptable, less preferred method of freeze protection is the use of an aluminum or stainless steel insulated enclosure. Figure 13 in Appendix C shows a typical protective enclosure.

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APPENDIX A. CROSS-CONNECTION CONTROL REQUIREMENTS

TABLE 1: CROSS-CONNECTION CONTROL GUIDELINES

(X Indicates Minimum Required Backflow Prevention Assembly)

SYSTEM/EQUIPMENT DESCRIPTION	METHOD/ASSEMBLIES REQUIRED TO PREVENT BACKFLOW				
	AIR GAP	ATMOSPHERIC VACUUM BREAKER	PRESSURE VACUUM BREAKER	DOUBLE CHECK VALVE	REDUCED PRESSURE
A/C Chilled Water Makeup					X
A/C Condenser Water Makeup					X
A/C Cooling Tower Makeup	X				X
Air Compressor Coolant					X
Aspirator, Medical					X
Autoclave & Sterilizer	X				
Boiler Feed Line				X	
Bathtub Below Rim Filler					X
Bedpan Washer		X			
Brine Tank	X				X
Bottle Washer	X				X
Chemical Feeder Tank	X				X
Chlorinator					X
Coffee Urn	X				
Cuspidor, Dental	X				
Demineralized System					X
Dishwasher	X				X
Degreasing Equipment	X				X
Developing Tank	X				X
Detergent Dispenser	X				X
Dock Potable Water Supply					X
Dock Firex Water Supply				X	
Etching Tank	X				X
Fire Standpipe System*				X	
Firex Foam System					X
Flexible Shower Heads		X			
Fountain, Ornamental	X				X
Floor Drain, Trap Primer	X				
Garbage Can Washer		X			
Garbage Disposer	X	X			

TABLE 1 (continued)

SYSTEM/EQUIPMENT DESCRIPTION	METHOD/ASSEMBLIES REQUIRED TO PREVENT BACKFLOW				
	AIR GAP	ATMOSPHERIC VACUUM BREAKER	PRESSURE VACUUM BREAKER	DOUBLE CHECK VALVE	REDUCED PRESSURE
Hose Faucets/Bibbs		X			
Hot Water Generator Feed				X	
Ice Maker	X			X	
Irrigation Systems			X		
Irrigation Systems with Chemical Feed				X	
Janitor's Closet	X	X			
Lab Equipment	X	X			X
Laundry Machine	X				X
Lavatory	X				
Makeup Tank	X			X	X
Misc. Equip. Coolant Water				X	X
Pump Priming Lines	X				X
Pump Water Ejector					X
Photo Lab Sinks	X				X
Photostat Equipment	X				X
Pipette Washer	X				
Potato Peeler	X				
Processing Tanks	X	X		X	X
Stills	X	X		X	X
Sitz Bath	X	X			
Sprinkler System (Fire)*				X	
Solution Tanks	X				X
Sanitary Sewer	X				
Storm Sewer	X				
Swimming Pool	X				
Steam Cleaner	X	X			X
Steam Table	X	X			
Ultrasonic Baths	X				
Water Treatment Tanks	X			X	X
Water Well Secondary System	X				X
Facility Potable Water Supply (Containment)					X

* Required only if system contains fire department connection or black pipe.

APPENDIX B. PARAMETERS FOR BACKFLOW PREVENTER DEVICES

TABLE 2: PARAMETERS FOR BACKFLOW PREVENTER DEVICES

Nominal Size (psi)	Rated Flow* (gpm)	Maximum Allowable Pressure Loss at Rated Flow	
		Reduced Pressure Device (psi)	Double Check Valve Device (psi)
1/2	12	22	10
3/4	30	20	10
1	50	18	10
1 1/4	75	18	10
1 1/2	100	16	10
2	160	16	10
2 1/2	225	16	10
3	320	15	10
4	500	14	10
6	1000	14	10
8	1600	14	10
10	2300	14	10

* Maximum recommended operating flow rate for which pressure loss is calculated.

APPENDIX C. STANDARD DETAILS

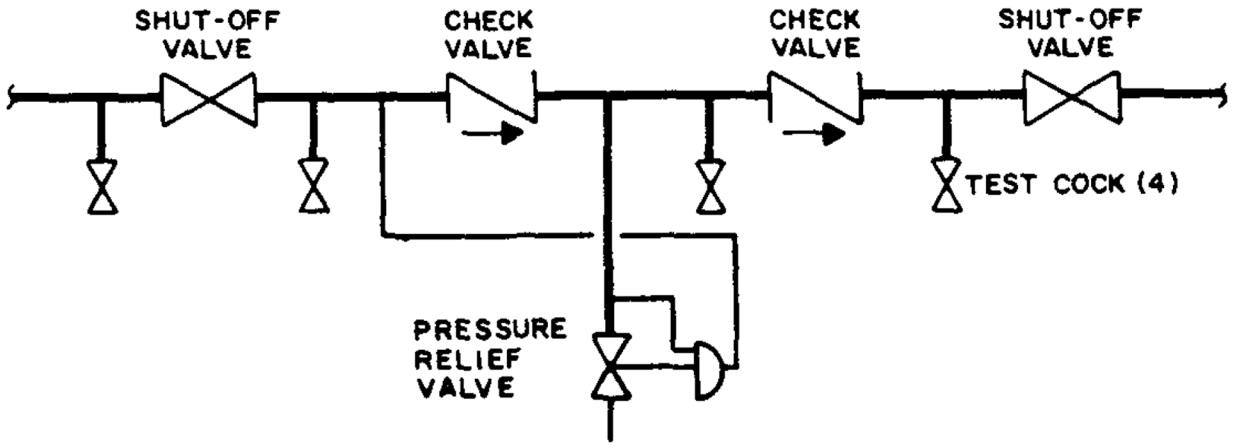

Figure 1: Schematic of Reduced Pressure Principle Assembly

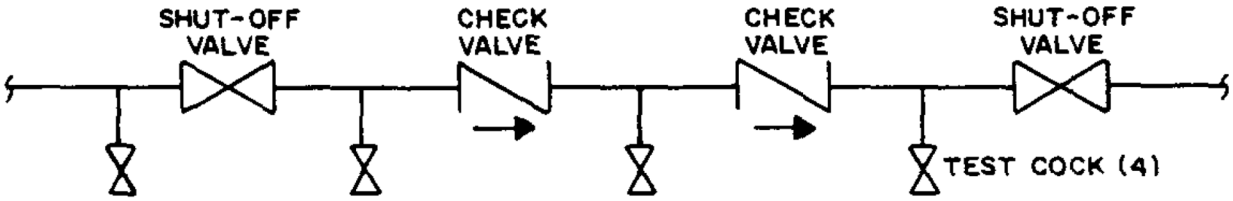

Figure 2: Schematic of Double Check Valve Assembly

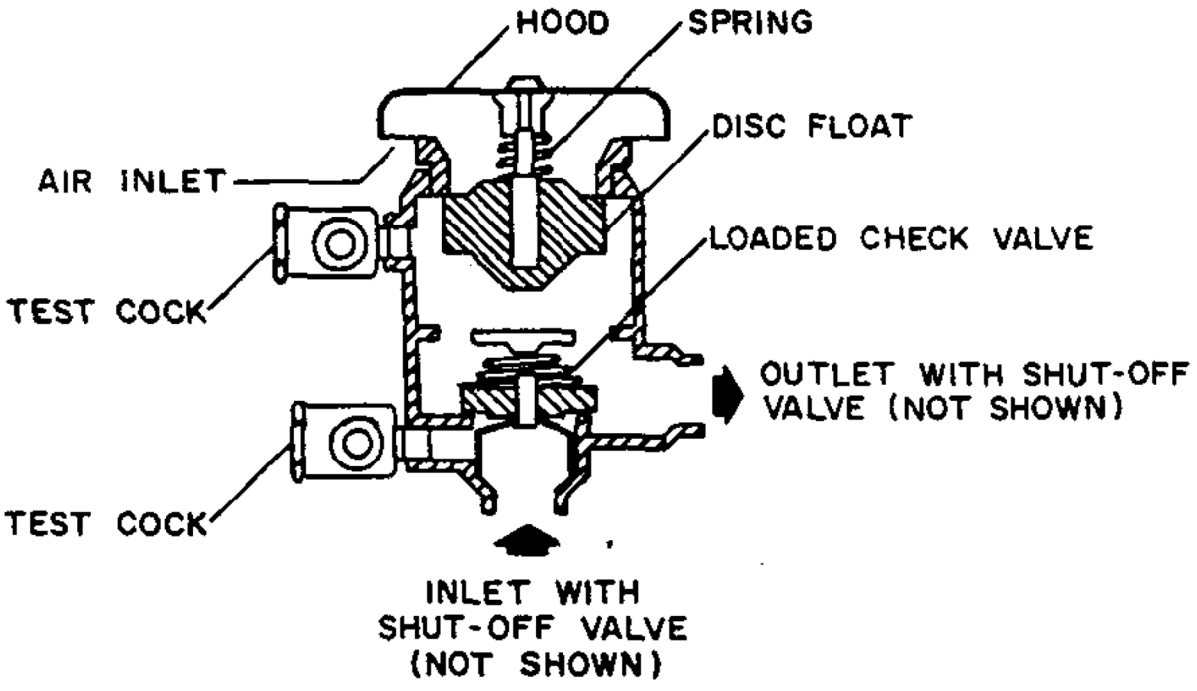

Figure 3: Pressure Vacuum Breaker

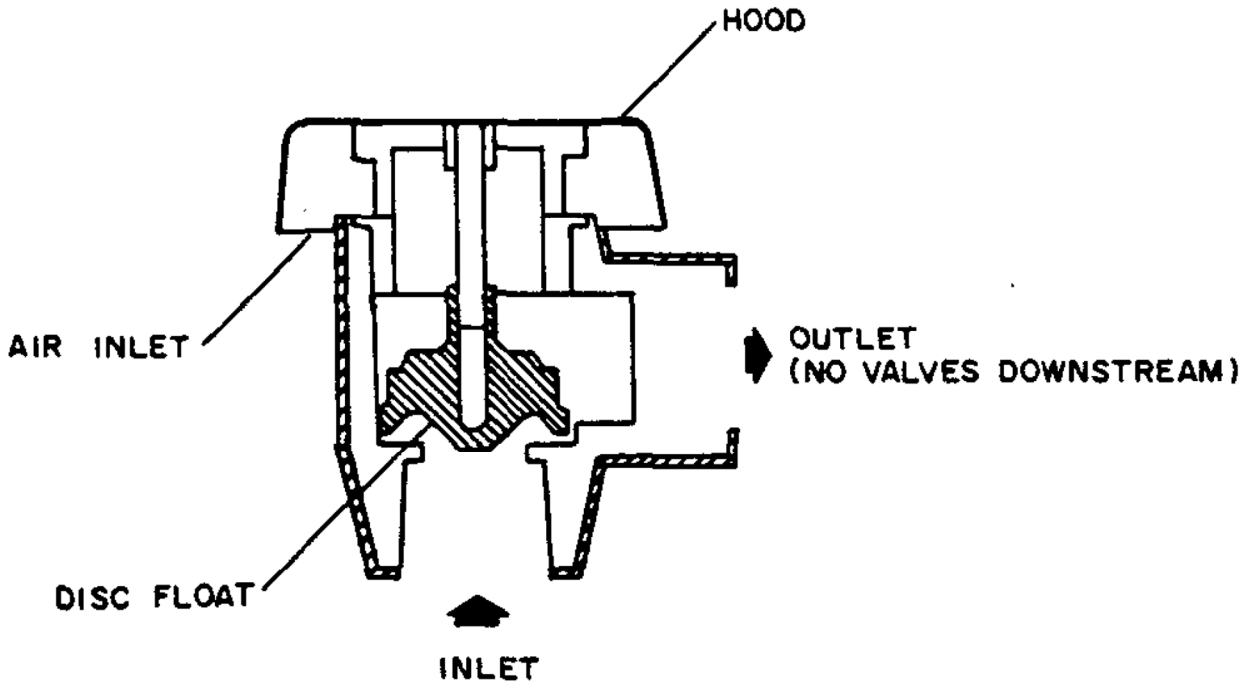

Figure 4: Atmospheric Vacuum Breaker

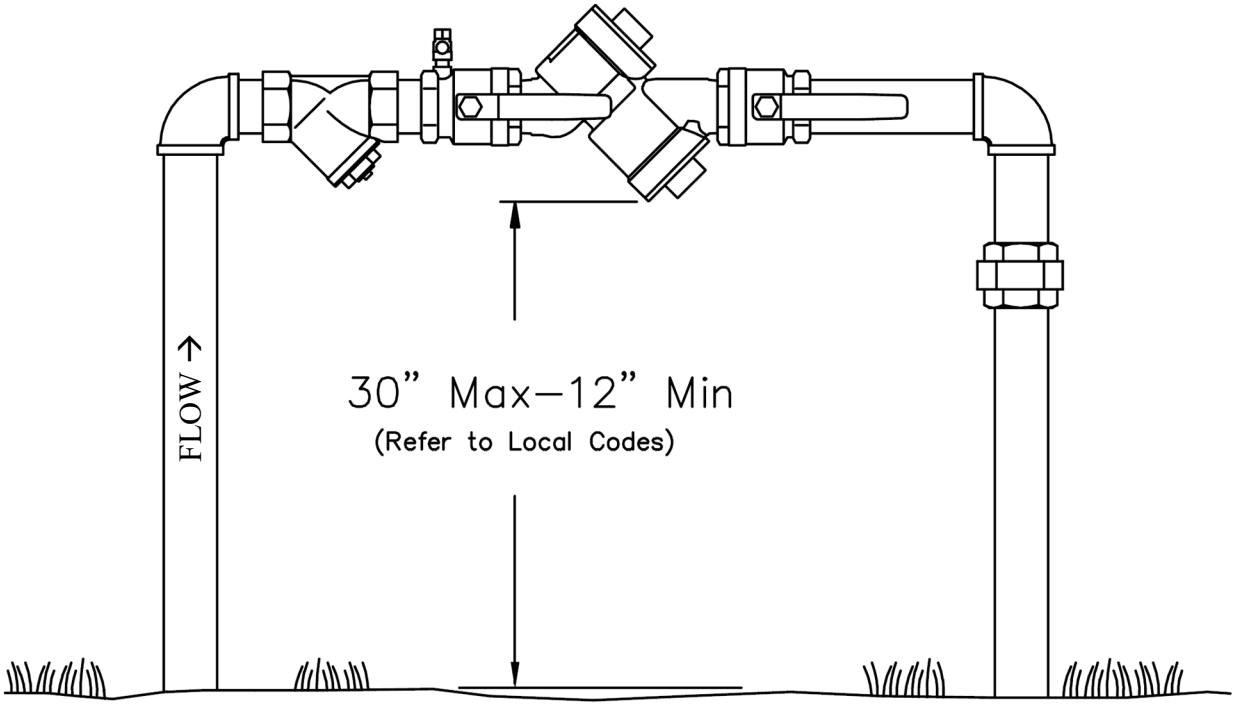

Figure 5: Double Check Vavle Assembly Insallation (2" and Smaller)

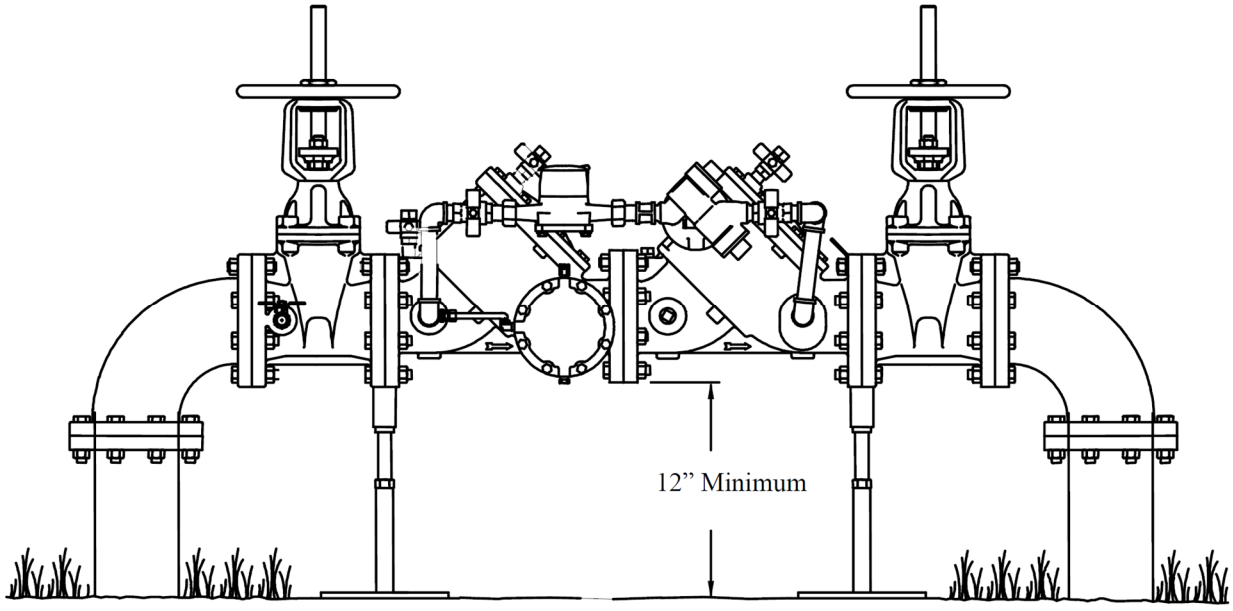

Figure 6: Reduced Pressure Backflow Preventer Installation (2-1/2" and above)

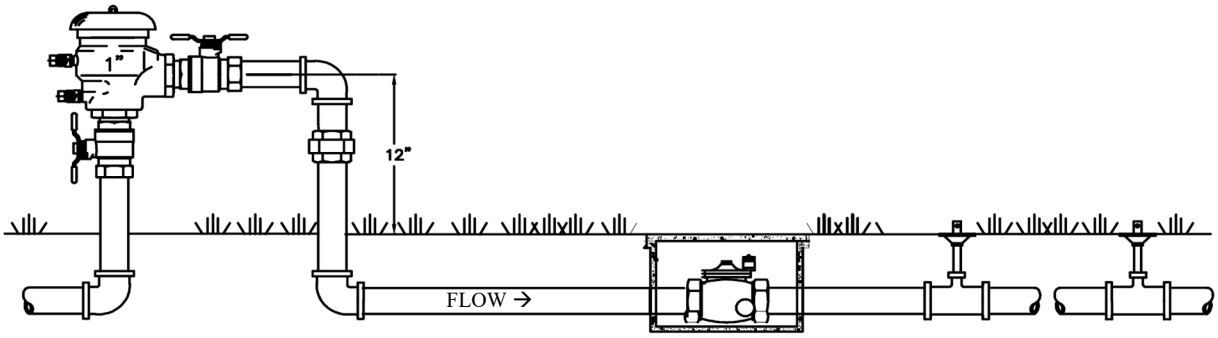

Figure 7: Pressure Vacuum Breaker Assembly Installation

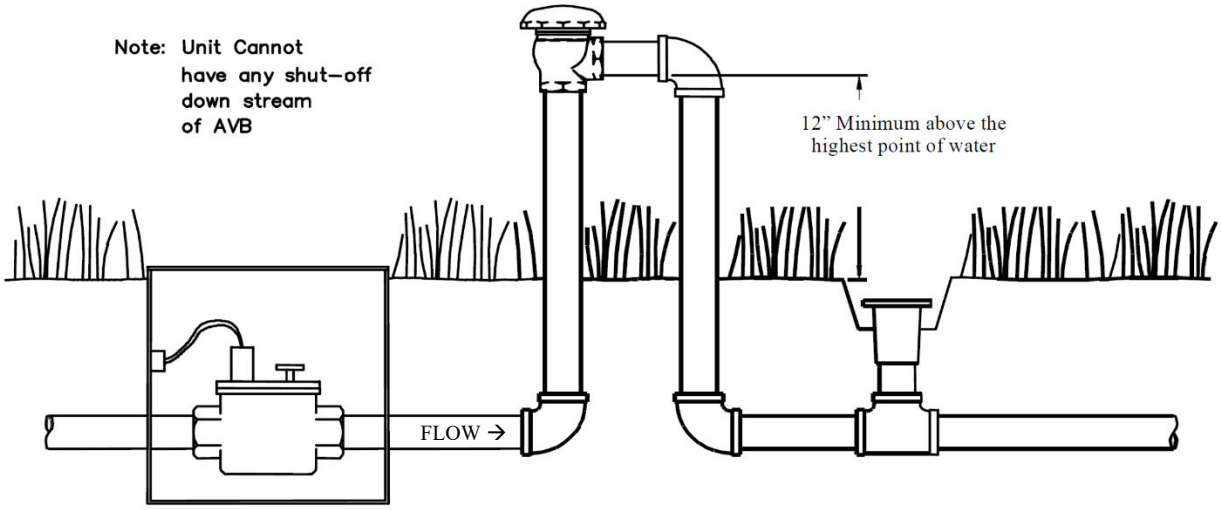

Figure 8: Atmospheric Vacuum Breaker Assembly Installation

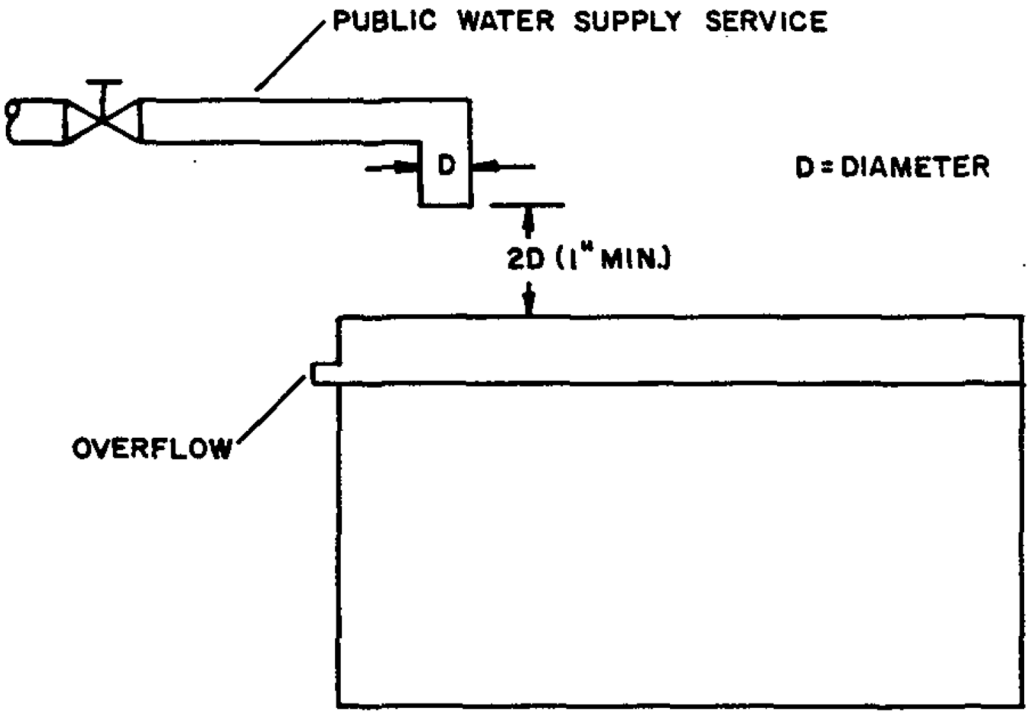

Figure 9: Safe Air Gap - Ground Level Storage Tank

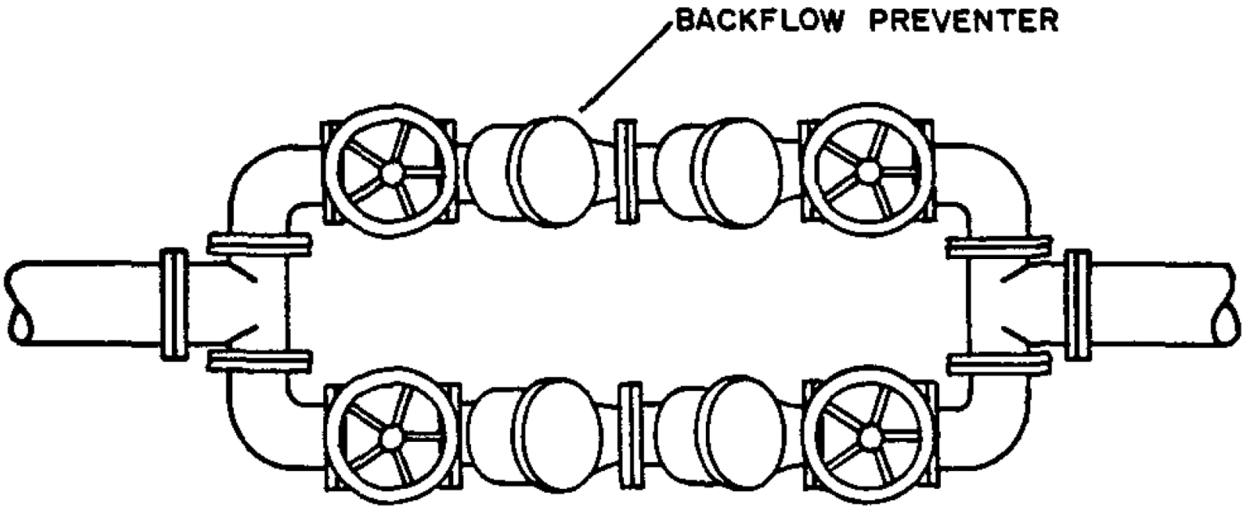

Figure 10: Parallel Installation

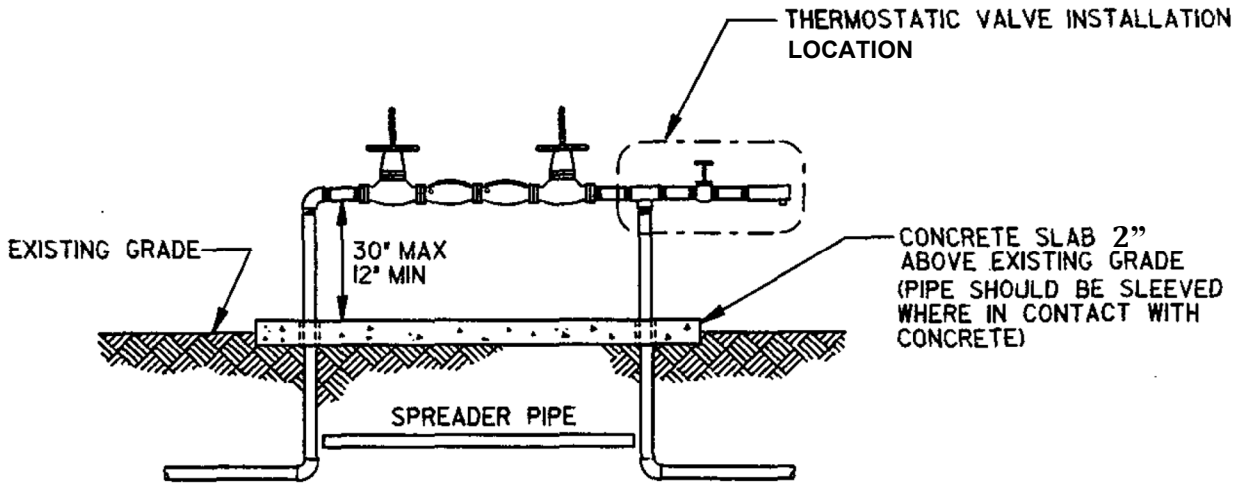

Figure 11: Typical Thermostatic Freeze Protection Valve Installation

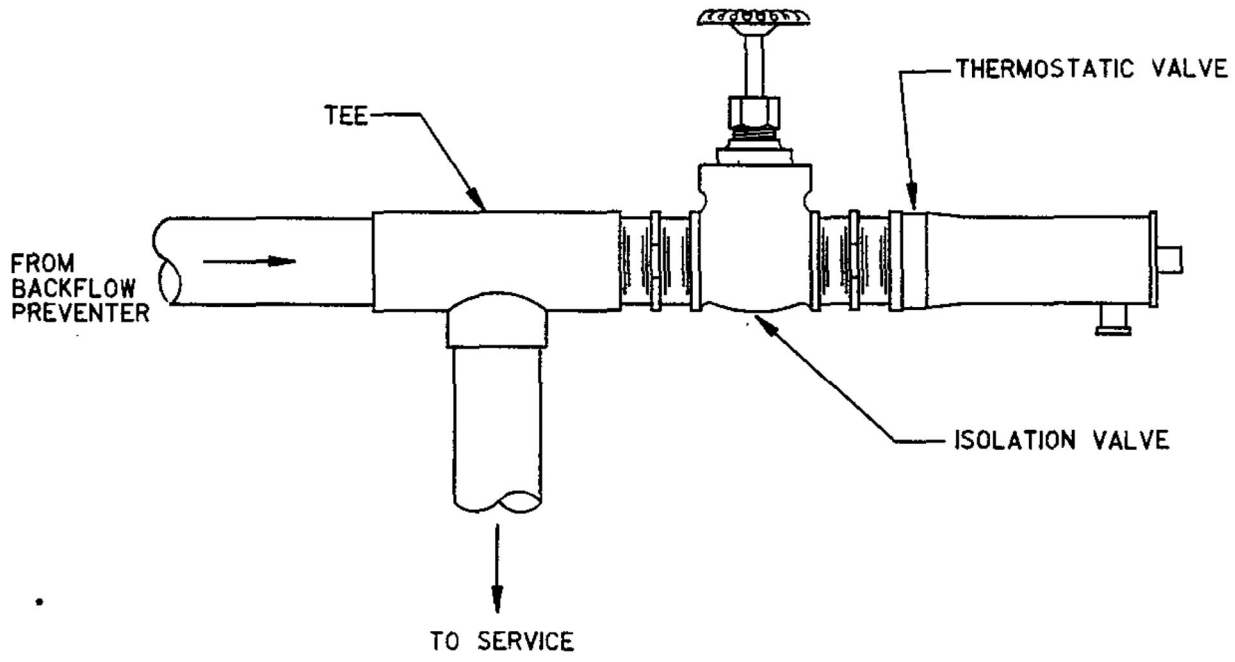

Figure 12: Detail, Thermostatic Freeze Protectin Valvce Installation

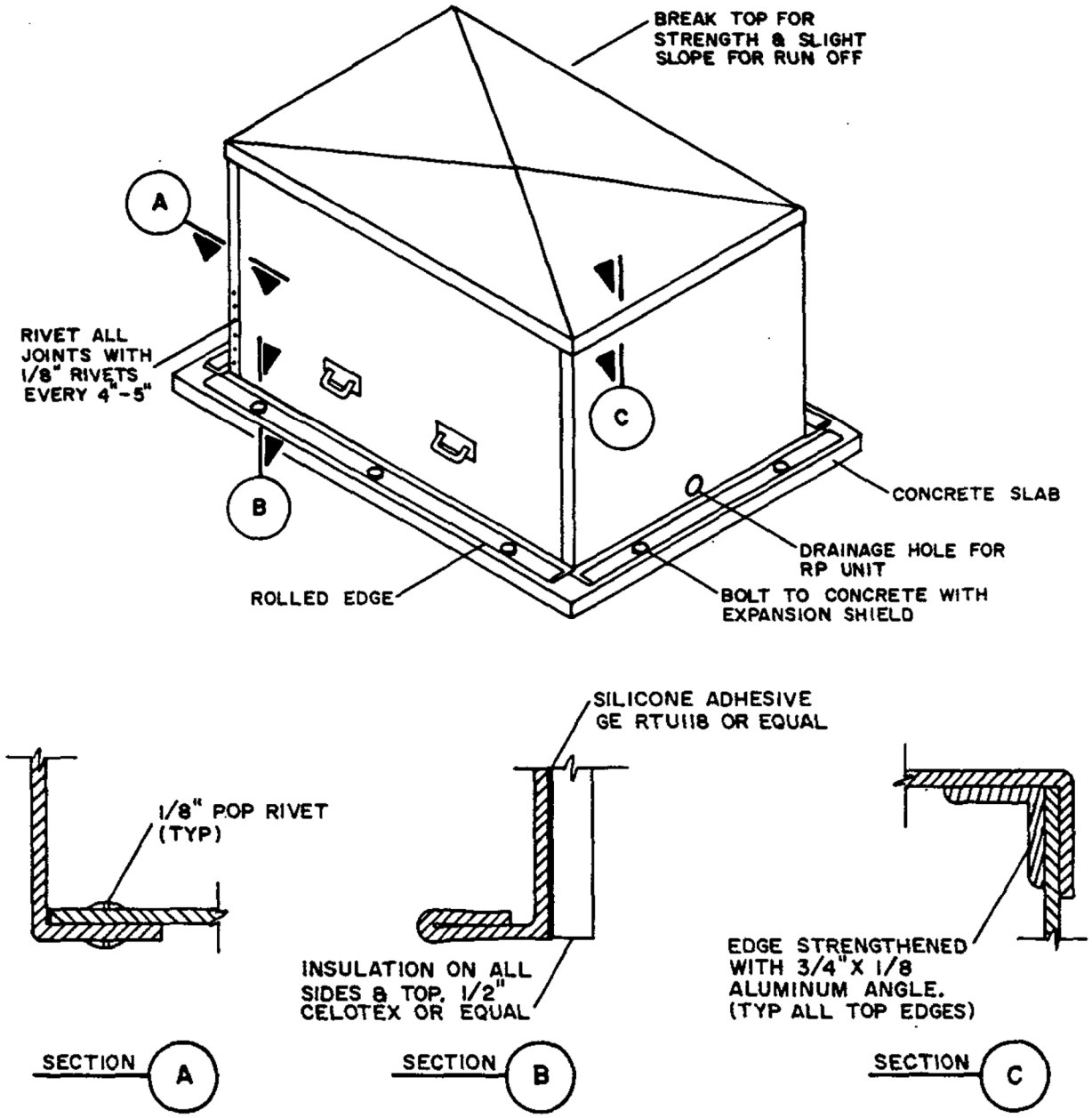

Figure 13: Freeze Protection Cover