Industrial Maintenance
Piping Training System

Backflow Prevention Devices

Job Sheets - Courseware Sample

20640-F0

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Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

Symbol	Description
⚠ DANGER	**DANGER** indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
⚠ WARNING	**WARNING** indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
⚠ CAUTION	**CAUTION** indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
CAUTION	**CAUTION** used without the *Caution, risk of danger* sign ⚠, indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger
	Caution, lifting hazard
	Caution, hand entanglement hazard
	Notice, non-ionizing radiation
⎓	Direct current
∿	Alternating current
⎓ ∿	Both direct and alternating current
3∿	Three-phase alternating current

Safety and Common Symbols

Symbol	Description
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (supply)
	Off (supply)
	Equipment protected throughout by double insulation or reinforced insulation
	In position of a bi-stable push control
	Out position of a bi-stable push control

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Preface

Backflow prevention (BFP) is of crucial importance for authorities responsible for the supply of potable water to populations. To make sure that public water is safe, cross-connections in the water distribution system with potentially harmful fluids have to be identified. Proper backflow prevention devices must then be installed to prevent the contamination of potable water.

The BFP Training System, model 46105-F0 or model 46105-J0, features the most common backflow prevention devices used in typical residential and commercial installations. The system will be used to study and perform test procedures on BFP devices. The system will also be used to teach students how to enforce the safety rules to be followed when working at industrial sites.

A mobile workstation forms the basis of the system. It includes various BFP devices and several other components such as a centrifugal pump, a flowmeter, valves, and pipes. Using modern, commercial-grade equipment is helpful in teaching theoretical and hands-on knowledge required to work in backflow prevention.

We invite readers of this manual to send us their tips, feedback, and suggestions for improving the book.

Please send these to did@de.festo.com.

The authors and Festo Didactic look forward to your comments.

About This Manual

Description

The topics covered in this manual are presented in the form of job sheets. Each job sheet consists of a theoretical section named *Information Job Sheet* followed by a series of tasks required to attain the learning objectives. The job sheets in this manual provide a systematic and realistic means of learning how to use and test backflow prevention devices.

Safety considerations

Safety symbols that may be used in this manual and on the equipment are listed in the Safety Symbols table at the beginning of the manual.

Safety procedures related to the tasks that you will be asked to perform are indicated in each exercise.

Make sure that you are wearing appropriate protective equipment when performing the tasks. You should never perform a task if you have any reason to think that a manipulation could be dangerous for you or your teammates.

California proposition 65

Some components of the BFP Training System contain chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

Reference material

Refer to the textbook *Manual of Cross-Connection Control, 10th edition,* by the USC Foundation for Cross-Connection Control and Hydraulic Research as a reference manual.

You may also consult the *Field Testing Backflow Preventers DVD* from the USC Foundation.

Appendices

The appendices included in this manual are:

Appendix A - *Basic Safety Procedures*, lists the basic safety procedures to be performed before you begin a job sheet.

Appendix B - *Lockout/Tagout Procedure*, describes the procedure to follow when de-energizing the BFP Training System.

Appendix C - *Start-up Procedure for the Centrifugal Pump*, describes the procedure to follow when starting-up the centrifugal pump.

Appendix D - *Conversion Table*, presents the factors to apply to convert U.S. customary units to SI units and vice versa.

About This Manual

Appendix E - *BFP Add-Ons to the Piping Training System*, describes how to obtain the BFP Training System from the Piping Training System.

Systems of units

Both U.S. customary units and SI units are used in this manual. The values associated with the SI units are shown between parentheses. When you have to fill a table with measurement results or plot a graph, do not forget to indicate the units associated with your measurement results.

Photographs in the job sheets

The photographs in the job sheets were taken at the time the BFP Training System was designed. Although every effort is made to keep these pictures up to date, you may notice some differences between what is shown in the pictures and the components you received. This is normal and reflects the company's commitment toward continuous product improvement.

To the Instructor

You will find in this Instructor Guide all the elements included in the Student Manual together with the answers to all questions, results of measurements, graphs, explanations, suggestions, and, in some cases, instructions to help you guide the students through their learning process. All the information that applies to you is placed between markers and appears in red.

Accuracy of measurements

The numerical results of the hands-on exercises may differ from one student to another. For this reason, the results and answers given in this manual should be considered as a guide. Students who correctly performed the exercises should expect to demonstrate the principles involved and make observations and measurements similar to those given as answers.

Care and maintenance of the BFP Training System

Every week, you should:

- Check the general condition of the Training System.
- Make sure the pump-to-tank connections, located under the drip trays, are leak free.
- Make sure the drip trays are solidly fixed to the mobile workstation.

Treating and changing the water

The tank must be filled with approximately 18 U.S. gallons (68 liters) of fresh water, i.e., the water level should be approximately five inches from the top. The water circulating in the system must be treated to remain clean and hygienic for extended periods of time. To do so, it is important to add the following solutions to the water the first time you fill the tank and every time you change the water thereafter:

- 2 fl oz (60 ml) of Antibacterial, p/n 38097.
- 8 fl oz (240 ml) of Rust Inhibitor, p/n 38096.

You should replace the water in the reservoir every 6 months, or whenever it begins to cloud.

Sample
Extracted from
the Job Sheets Student
and the Job Sheets Instructor

Backflow Prevention Principles

Glossary

Cross-connection

A cross-connection, as illustrated in Figure 24, is an actual or possible connection between a potable water system and another source of non-potable liquids.

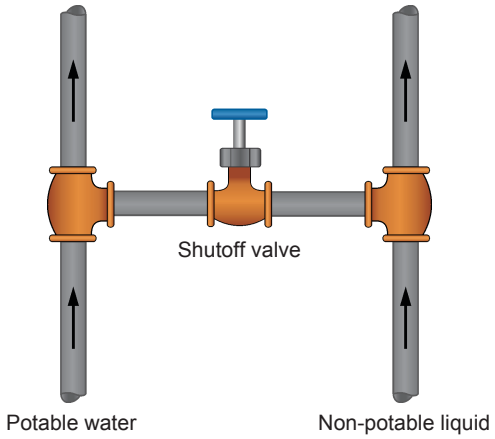

Figure 24. Cross-connection.

Backflow

Backflow is an unwanted flow reversal of liquids into the potable water distribution system.

Fluids tend to flow from the highest to the lowest pressure in the system. Controlling leaks and pressure is key to backflow prevention.

Backpressure

Backpressure is backflow due to an increase in pressure in the downstream piping system.

Figure 25 shows a backpressure scenario, where chemicals backflow into the main supply due to a check valve leaking on a pressurized boiler in an industrial plant. Contaminated water is then supplied to homes and restaurants downstream of the cross-connection.

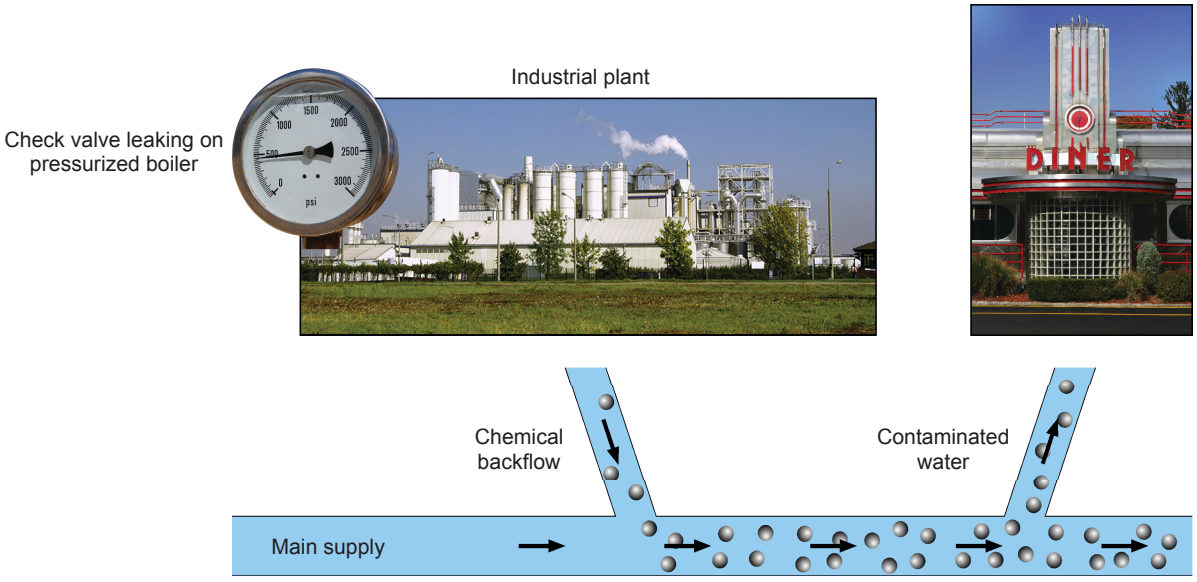

Figure 25. Backpressure scenario.

Backsiphonage

Backsiphonage is backflow due to the system pressure decreasing below the atmospheric pressure.

Figure 26 shows a backsiphonage scenario, where a main line repair leading to a pressure drop causes the siphoning of diluted pesticides from a home upstream of the repair site.

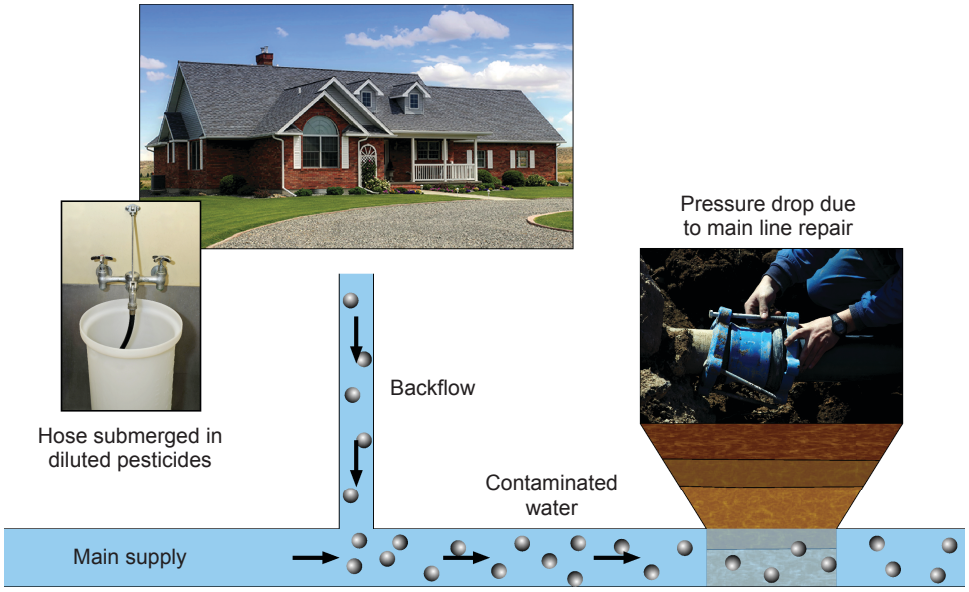

Figure 26. Backsiphonage scenario.

How to choose a BFP device?

Three conditions govern the choice of the appropriate BFP device for a given application:

- **Degree of hazard**. The source of backflow could be a contaminant (health hazard) or a pollutant (non-health hazard).
- **Types of backflow**. The cross-connection could be subject to backsiphonage only, or to both backpressure and backsiphonage.
- **Continuous operation**. The operating time of the BFP device over a 24-hour period must be established.

Types of backflow prevention devices

Some of the most common backflow prevention devices used in water distribution systems are presented below. Backflow prevention devices must be tested on a regular basis by qualified personal. Figure 27 shows examples of backflow prevention devices.

Figure 27. Backflow prevention devices.

Air gap

A physical separation between the end of a pipe supplying potable water and an open vessel is an air gap. It must be at least twice the size of the pipe diameter, but no less than 1 in (2.54 cm), as shown in Figure 28.

The air gap can be used under continuous operation and any kind of backflow and degree of hazard. Using an air gap unfortunately leads to losses of the supplied pressure and sanitary control, because the potable water is exposed to the atmosphere.

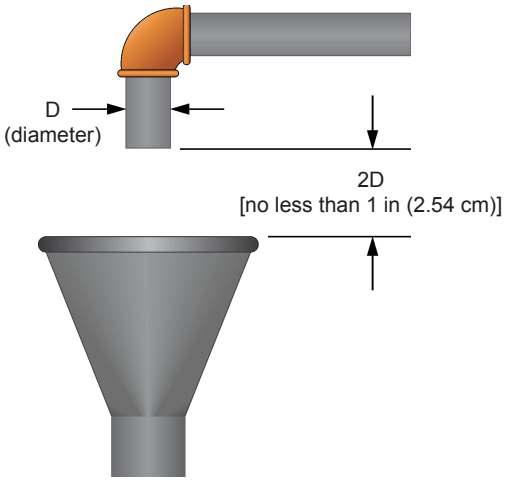

Figure 28. Air gap.

Check valve

A check valve permits the flow in only one direction and is a part of many approved backflow prevention assemblies. Figure 29 illustrates a spring loaded check valve with a normal flow and a reverse flow.

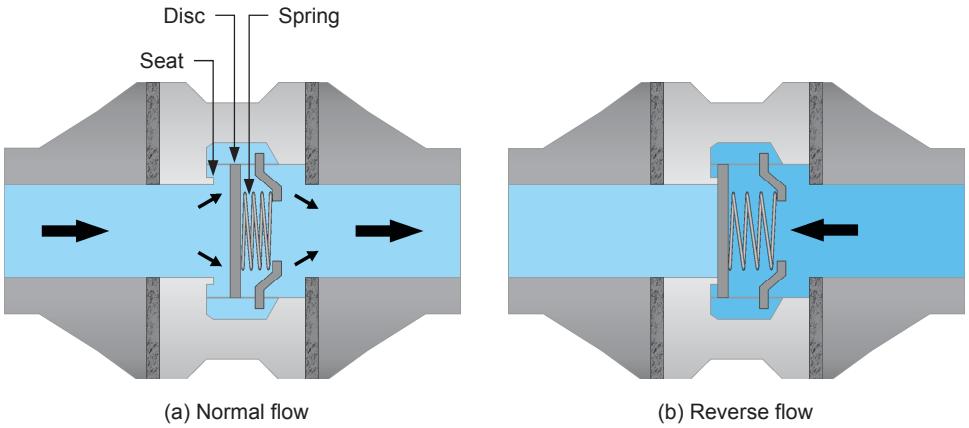

Figure 29. Check valve principle.

Atmospheric Vacuum Breaker (AVB)

In an Atmospheric Vacuum Breaker, the poppet is pushed to the upper seat when water flows through the assembly: the air inlet valve is closed. The poppet is pulled to the lower seat when the flow stops or when there is a backsiphonage condition: the air inlet valve opens. Air can thus flow in through the air inlet port. Figure 30 shows the operating principle of an Atmospheric Vacuum Breaker.

An Atmospheric Vacuum Breaker can be used to protect against health or non-health hazards in a backsiphonage condition only. It cannot protect against backpressure and should not be used in continuous operation. This BFP device cannot be tested once it is installed.

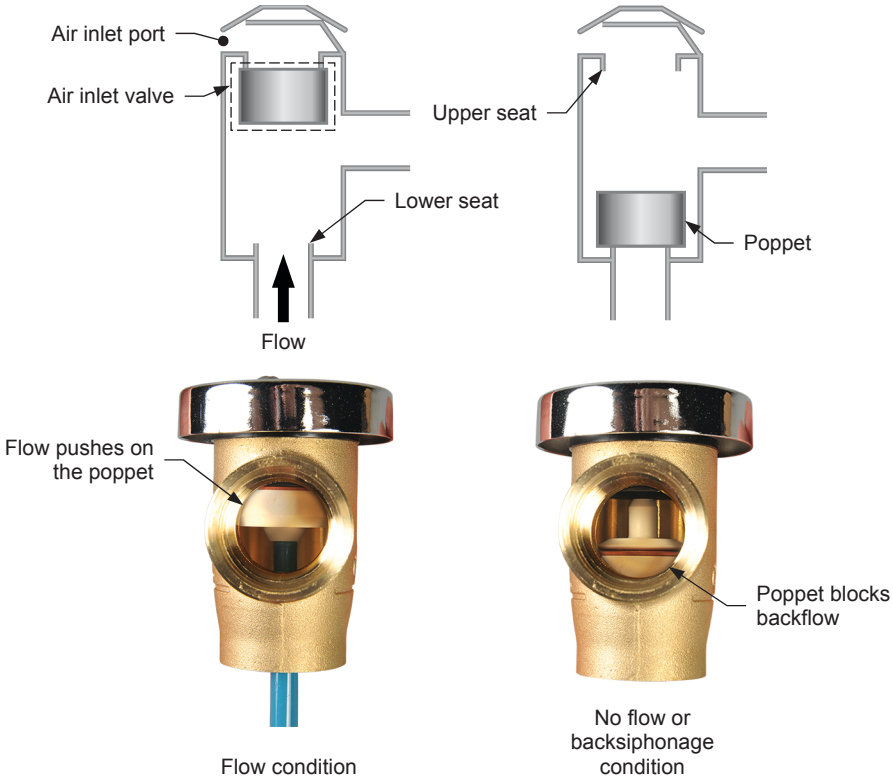

Figure 30. Operating principle of an Atmospheric Vacuum Breaker.

Spill-Resistant Vacuum Breaker (SVB)

A Spill-Resistant Vacuum Breaker consists of one loaded check valve and one loaded air inlet valve. It can be used under continuous operation to protect from backsiphonage only. It provides protection against health or non-health hazards. Figure 31 shows the features of a Spill-Resistant Vacuum Breaker.

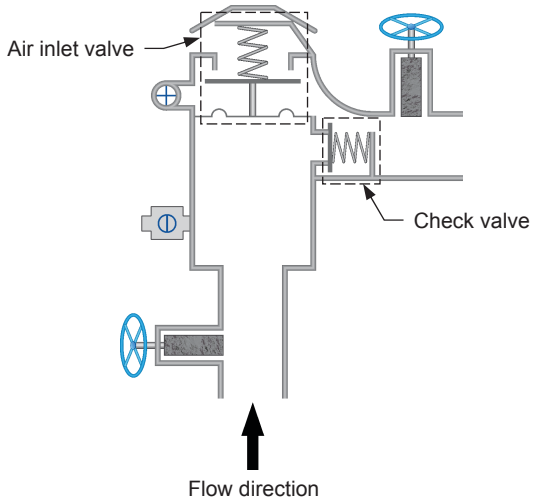

Figure 31. Features of a Spill-Resistant Vacuum Breaker.

Double Check Valve Assembly (DC)

A Double Check Valve Assembly, as illustrated in Figure 32, has two loaded check valves in series. It can be used under continuous operation to protect against backpressure and backsiphonage. A Double Check Valve Assembly can only be installed in cross-connections with pollutants.

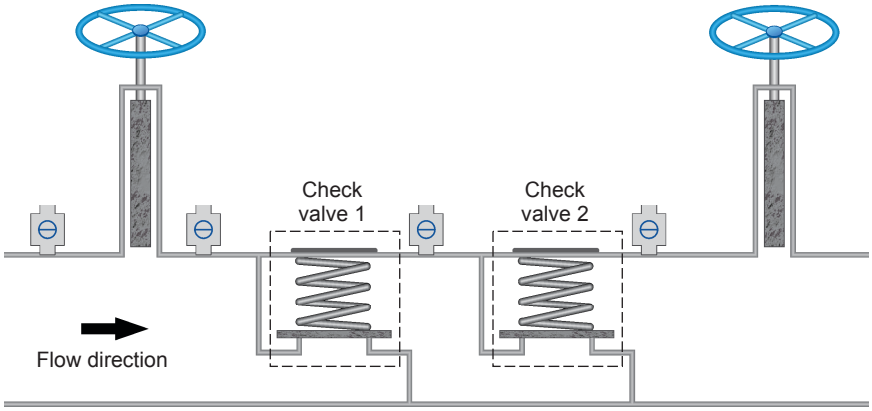

Figure 32. Features of a Double Check Valve Assembly.

Reduced Pressure Zone Assembly (RP)

A Reduced Pressure Zone Assembly is similar to a Double Check Valve Assembly, with an additional relief valve between the two loaded check valves, as shown in Figure 33. If one or both check valves are fouled and cannot prevent backflow, the contaminant or pollutant exits through the vent of the relief valve. A Reduced Pressure Zone Assembly provides protection against backsiphonage and backpressure and can be used under continuous operation.

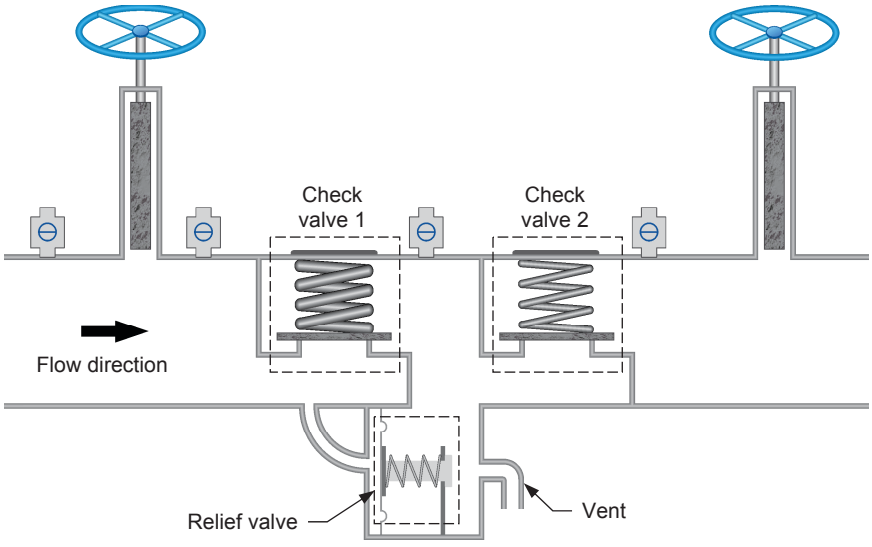

Figure 33. Features of Reduced Pressure Zone Assembly.

Backflow Prevention Principles

OBJECTIVE

To study the different roles of backflow prevention devices. To understand the operating principle of the Atmospheric Vacuum Breaker. To use the test kit and the sight tube to measure static pressure differences through BFP devices.

PROCEDURE

Applications of backflow prevention devices

1. Fill the following table regarding the applications of the backflow prevention devices included in the BFP Training System.

	Double Check Valve Assembly (DC)	Angled Double Check Valve Assembly (Angled DC)	Reduced Pressure Zone Assembly (RP)	Angled Reduced Pressure Zone Assembly (Angled RP)	Spill-Resistant Vacuum Breaker (SVB)	Atmospheric Vacuum Breaker (AVB)
Application						
Backsiphonage						
Backpressure						
Non-health hazard (pollutant)						
Health hazard (contaminant)						
Continuous operation						

	Double Check Valve Assembly (DC)	Angled Double Check Valve Assembly (Angled DC)	Reduced Pressure Zone Assembly (RP)	Angled Reduced Pressure Zone Assembly (Angled RP)	Spill-Resistant Vacuum Breaker (SVB)	Atmospheric Vacuum Breaker (AVB)
Image						
Backsiphonage	X	X	X	X	X	X
Backpressure	X	X	X	X		
Non-health hazard (pollutant)	X	X	X	X	X	X
Health hazard (contaminant)			X	X	X	X
Continuous operation	X	X	X	X	X	

Safety measures

2. Perform the Basic Safety Procedures listed in Appendix A.

3. Perform the Lockout/Tagout Procedure listed in Appendix B.

Pressurizing the BFP devices

4. Familiarize yourself with the flows that will be established in the next steps of this procedure.

   The main flow will go through the Spill-Resistant Vacuum Breaker (SVB) and the Angled Double Check Valve Assembly (Angled DC). See Figure 34.

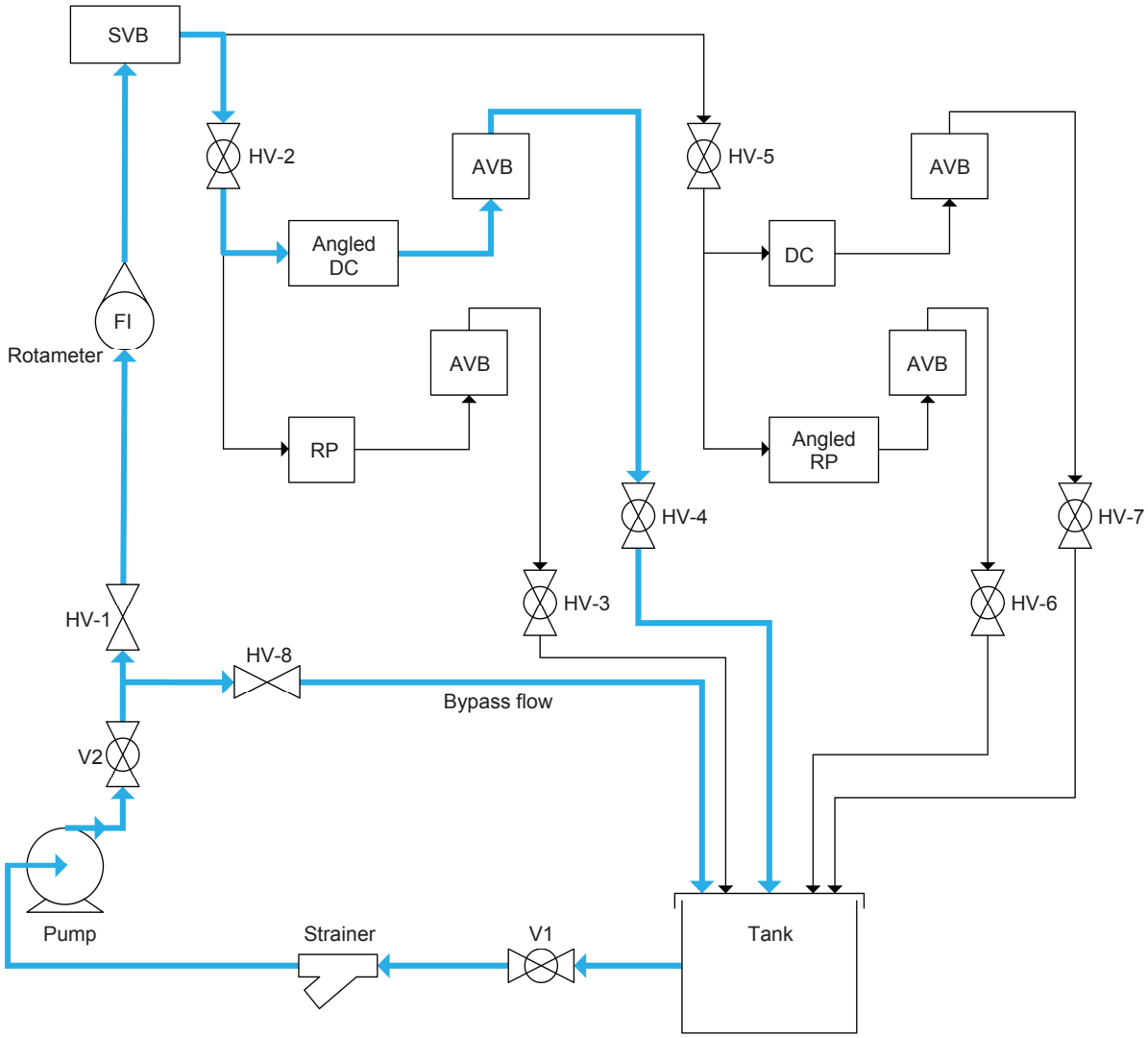

Figure 34. Flows in the BFP Training System.

5. Remove the screws on top of the canopy of the Atmospheric Vacuum Breaker located downstream of the Angled Double Check Valve Assembly.

6. Remove the canopy and look inside the Atmospheric Vacuum Breaker. The poppet should be down on the lower seat and you should see the downstream piping of the Atmospheric Vacuum Breaker, as seen on Figure 35.

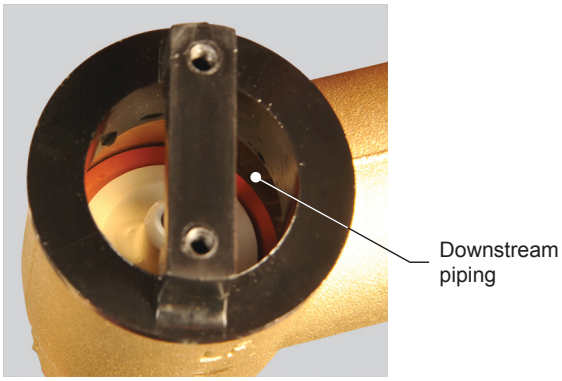

Figure 35. Atmospheric Vacuum Breaker with air inlet valve open.

7. Make sure the upstream and downstream shutoff valves of the Spill-Resistant Vacuum Breaker and the Angled Double Check Valve Assembly are closed.

8. Set the valves as follows (O: open, C: closed, SO: slightly open, between a quarter turn and half a turn):

Table 3. Status of the valves.

V1	V2	HV-1	HV-2	HV-3	HV-4	HV-5	HV-6	HV-7	HV-8
O	O	O	O	C	C	C	C	C	SO

For the second team working on the other side of the mobile workstation, V2 is replaced by V4. If there is no team on the other side, then V4 must be closed.

9. Perform the Start-Up Procedure for the Centrifugal Pump listed in Appendix C.

If a team is working on the other side of the mobile workstation, make sure that it is ready to pressurize their BFP devices, or aware that you will start the pump.

Pressurizing the Spill-Resistant Vacuum Breaker

10. Make sure the test cock and the bleed screw of the Spill-Resistant Vacuum Breaker are closed. Slowly open shutoff valve 1. Wait 5 seconds. Slowly open shutoff valve 2.

Pressurizing the Angled Double Check Valve Assembly

11. Make sure the test cocks of the Angled Double Check Valve Assembly are closed. Slowly open shutoff valve 1. Wait 5 seconds. Slowly open shutoff valve 2. See Figure 36.

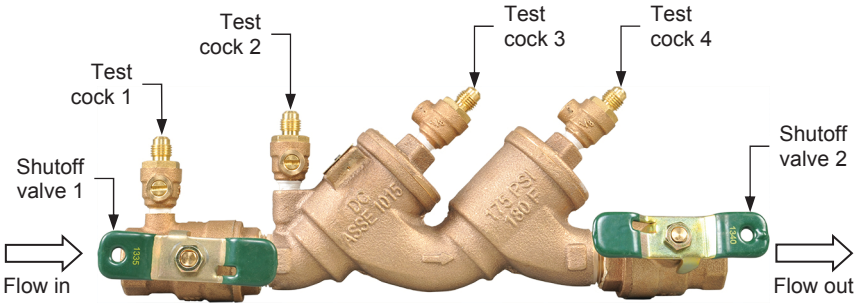

Figure 36. Angled Double Check Valve Assembly with shutoff valves open.

12. Slowly open HV-4 to establish flow in the circuit. Limit the opening to reach a maximum flow rate of approximately 3 gal/min (11.4 L/min).

13. Look inside the Atmospheric Vacuum Breaker. The air inlet valve should be closed when water flows through the Atmospheric Vacuum Breaker, as shown in Figure 37.

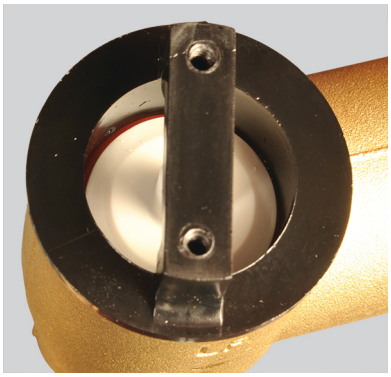

Figure 37. Atmospheric Vacuum Breaker with air inlet valve closed.

14. Replace the canopy and the screws on top of the canopy of the Atmospheric Vacuum Breaker.

Differential pressure across check valve 1 of the Angled Double Check Valve Assembly

Check valve 1 is located between test cock 2 and test cock 3.

15. Slowly open test cock 1 of the Angled Double Check Valve Assembly to bleed water from it. Close the test cock. Bleed and close test cock 2, test cock 3, and test cock 4 in the same manner. See Figure 38.

CAUTION

Be careful to direct the water bled from the test cock in a safe manner and away from the electrical components of the training system and the surrounding area. This is especially important for angled test cocks.

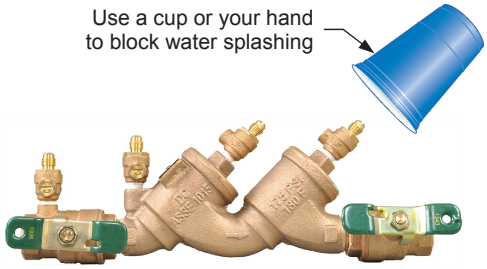

Figure 38. Bleeding an angled test cock in a safe manner.

16. Install the sight tube to test cock 3. See Figure 39.

Figure 39. Sight tube connected to test cock 3.

17. Make sure all the needle valves on the test kit are closed.

18. Connect the red hose between test cock 2 and the high pressure side of the test kit.

19. Fully open test cock 2. Bleed the high pressure side bleed needle valve in a safe manner. Close the high pressure side bleed needle valve.

20. Open test cock 3 to fill the sight tube completely. Close test cock 3.

21. Close shutoff valve 2. The test kit must be held at the same level as the water in the sight tube, as shown in Figure 40. Close shutoff valve 1.

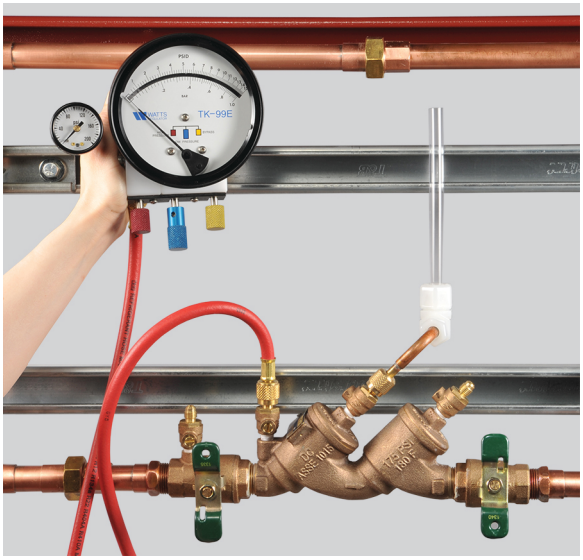

Figure 40. Test kit at the same level as the water in the sight tube.

22. Slowly open test cock 3 to the fully open position. When water stops flowing from the sight tube, or is no more than a drip, and when the reading on the gauge stabilizes, record the differential pressure across check valve 1.

The differential pressure across check valve 1 should be 1 psid or greater in order for the check valve to be tight.

Differential pressure: _____

The differential pressure is between 1.0 psid and 2.0 psid (between 0.07 bar and 0.14 bar).

Consult the reference manual for diagnostics if the differential pressure across check valve 1 is lower than 1 psid. You may need to use the bleed-off valve assembly.

If test cock 3 is open too fast and the water level drops below the top of the sight tube, proceed as follows:

- *Close test cock 3.*
- *Open shutoff valve 1.*
- *Open test cock 3 to fill the sight tube completely.*
- *Close test cock 3.*
- *With the test kit held at the same level as the water in the sight tube, close shutoff valve 1.*
- *Go to step 22 of this job sheet.*

23. Close the test cocks.

24. Open shutoff valve 1. Slowly open shutoff valve 2 to re-establish flow.

25. Ask the instructor to check and approve your work.

26. Remove the sight tube. Remove the hose from the test kit and the system. Drain water from the sight tube and the hose into a drip tray. Fully open all the valves on the test kit.

27. Close shutoff valve 2 of the Spill-Resistant Vacuum Breaker, then close shutoff valve 1.

28. Stop the pump and perform the Lockout/Tagout Procedure listed in Appendix B. Set HV-4 to the fully open position.

29. Wipe off any water from the floor and the training system.

Name: _____ Date: _____

Instructor's approval: _____