White Paper

Air In Pipelines

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Introduction

The presence of air in a pipeline and its impact on operations is probably one of the most misunderstood phenomena in our industry today. Many operational problems are blamed on inadequate thrust blocking, improper pipeline bedding, etc. These problems include broken pumps, valves and pipe, as well as faulty instrumentation readings. In reality, many of these problems are not caused by improper installation of the equipment but by failure to de-aerate the pipeline. It has been said that if a pipeline is properly de-aerated, you can't guarantee against a line break. However, if you don't properly de-aerate a pipeline, you should be prepared for one.

Sources of Air

Air in a pressurized, operating pipeline comes from three primary sources. First, prior to start-up, the line is not empty - it is full of air. To entirely fill a pipeline with fluid, it is necessary to eliminate this air. As the line fills, much of this air will be pushed downstream to be released through hydrants, faucets, etc. But a large amount will become trapped at system high points (Figure 1). This phenomenon will occur because air is lighter than water and therefore, will gravitate to the high points. This volume of air will continuously be increased by the second and third sources as the system continues operation.

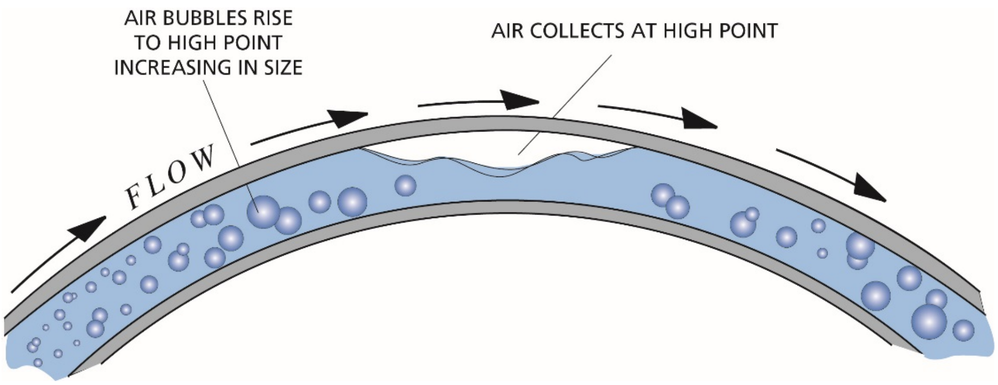

FIGURE 1. Air Collects at High Points

Source number two is the water itself. Water contains approximately 2% air by volume. During system operation, the entrained air will be continuously released from the water and once again accumulate at system high points. To illustrate the potential massive amount of air this 2% represents, consider the following: A 1000 ft. length of pipe could contain a pocket of air 20 ft. long if all the air accumulated in one location. Or a one mile length of pipe could contain a 100 ft. pocket. This would be true regardless of the size of the pipe.

The third source of air is that which enters through mechanical equipment (Figure 2). This includes air being forced into the system by pumps as well as air being drawn in through packing, valves, etc. under vacuum conditions. As one can see, a pressurized pipeline is never without air and typically the volume is substantial.

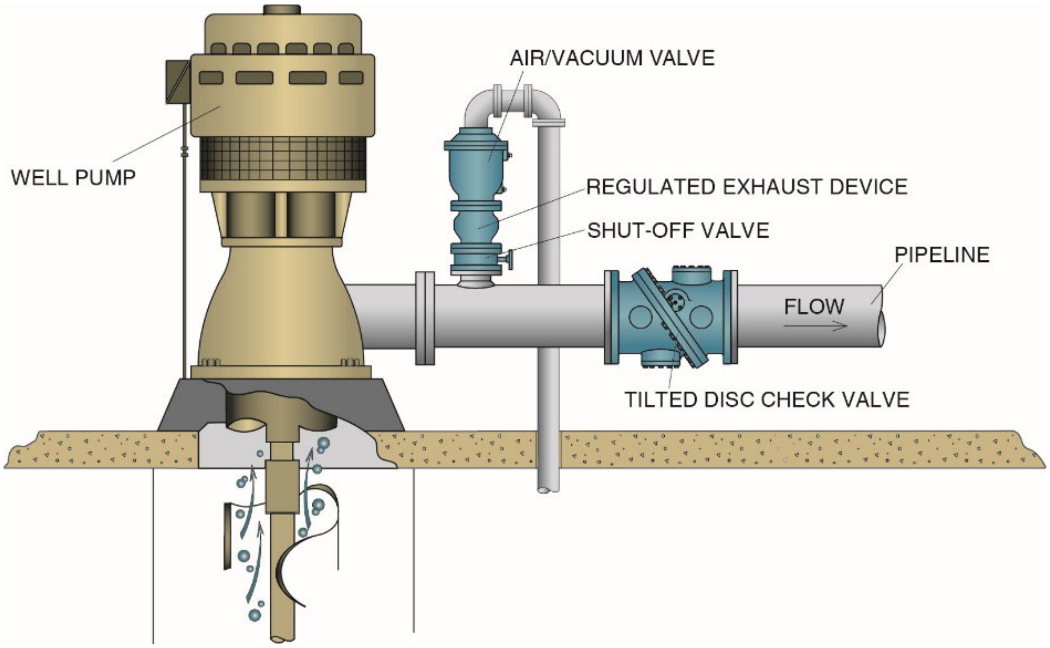

FIGURE 2. Air Through Mechanical Equipment

Impact of Air on System

Now that we have identified the air sources, let us consider the impact it will have on the system. Two problems are apparent. The pockets of air accumulating at high points can result in a line restriction (Figure 3). Like any restriction, the pockets of air increase headloss, extend pumping cycles and increase energy consumption. The presence of air can also promote corrosion of pipe and fittings. As air continues to accumulate at system high points, the fluid velocity increases as the fluid is forced through a smaller and smaller restricted pipe area.

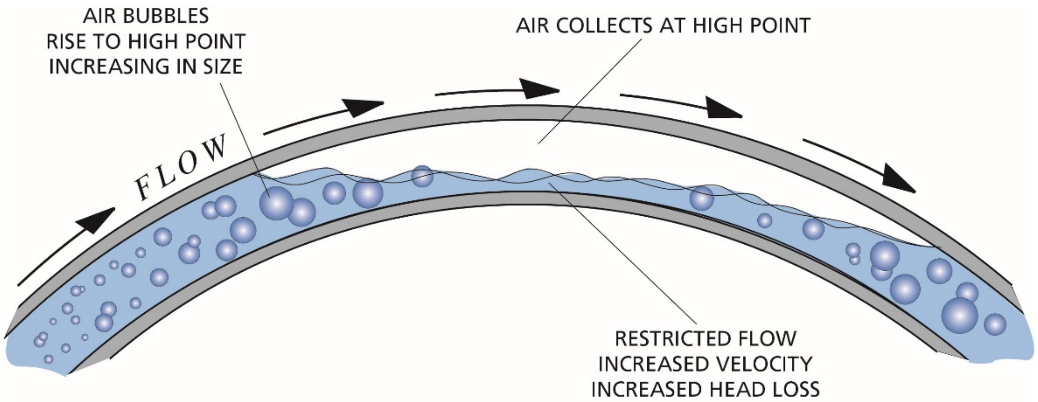

FIGURE 3. Pockets of Air

As the pockets grow, one of two phenomena will occur. The first possibility is a total stoppage of flow (Figure 4). If system dynamics are such that the air cannot be continuously removed by the increased fluid velocity and pushed downstream, then a pressure drop higher than pump capacity can develop, thereby stopping all flow.

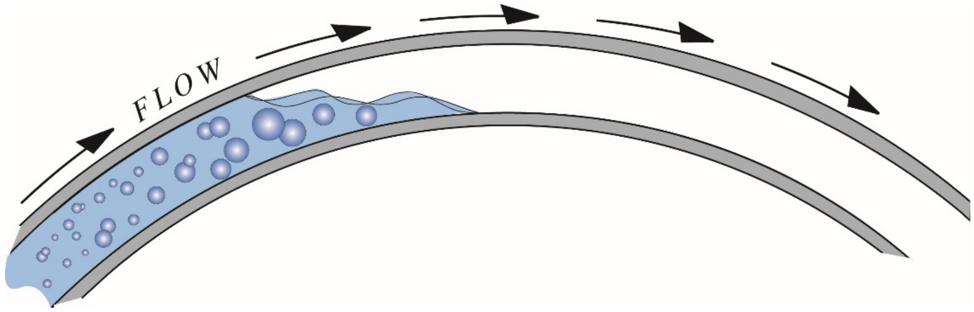

FIGURE 4. Total Stoppage of Flow

The second, and more likely occurrence, is that the increased velocity will cause all, or part of, the pocket to suddenly dislodge and be pushed downstream (Figure 5). The sudden and rapid change in fluid velocity when the pocket dislodges and is then stopped by another high point, which can, and often will, lead to a high pressure surge (i.e., water hammer). Serious damage to valves, fittings, gaskets, or even breakage of the line can occur. This is the most serious of the possible consequences of air being allowed to accumulate in system high points.

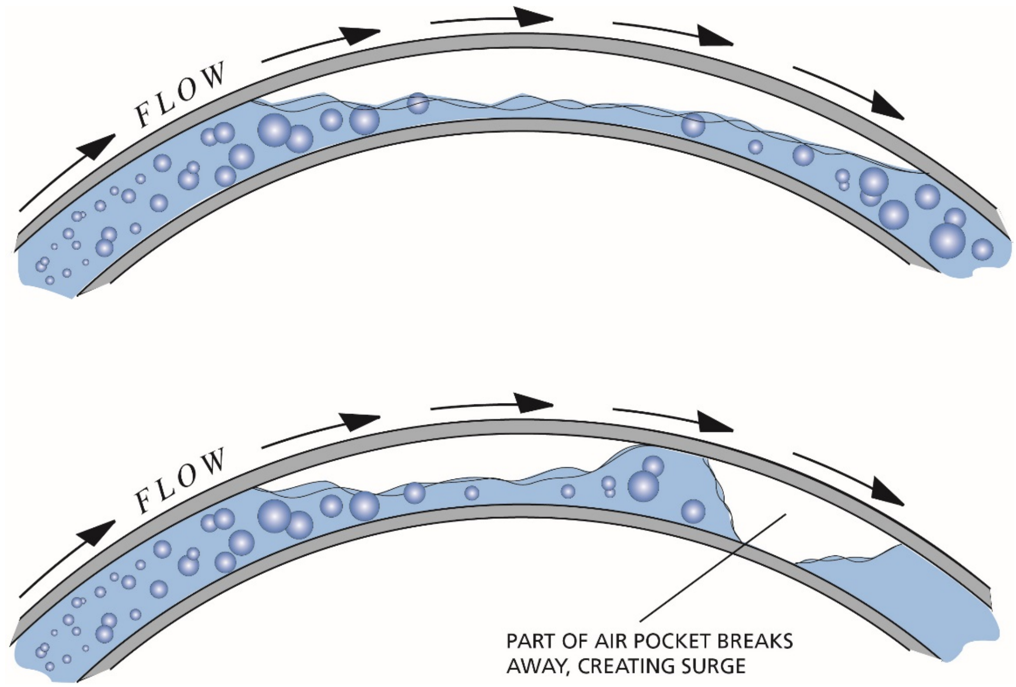

FIGURE 5. Air Pocket Can Result in a Surge

Historical Solutions

As we can see, air in a pressurized pipeline is a serious concern. Obviously, its removal will result in a more efficient, cost effective operation and potentially avoid more serious problems. In the early 1900's, engineers and waterworks personnel started developing an understanding of the problems associated with air and the search for a solution was on. Some depended on standpipes, believing that a large portion of the air would settle out through them. Many began placing manual vent valves at system high points to manually bleed off accumulated air. Unfortunately, it has proved impossible to predict when it is time to bleed the air. This proved impractical, especially on larger systems. Open fire hydrants (Figure 6) are frequently used under the assumption that all air in the pipeline will be released. Unfortunately, hydrants are generally connected to the side of the pipe leaving a substantial pocket of air trapped at the top. It should be noted that there are still a few municipalities using these methods.

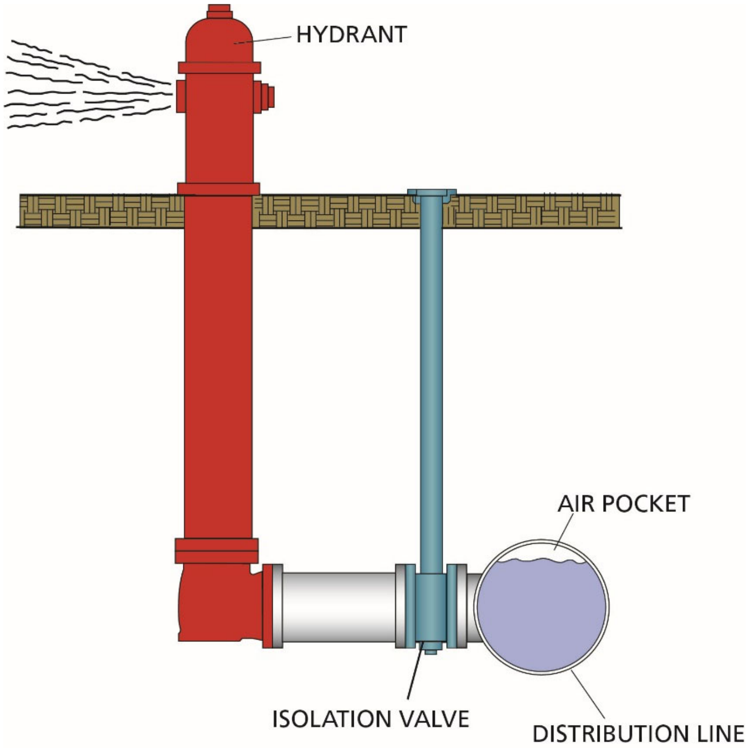

FIGURE 6. Open Fire Hydrant System

Air Valves: An Efficient, Reliable Alternative

Today, most municipalities utilize Automatic Air Valves. They are available in many different designs and configurations for a wide range of applications. Their function is to automatically release and admit air without operator assistance. Today, countless Air Valves are performing this task around the globe on a daily basis. Air Valves are manufactured in accordance with AWWA Standard C512 and available in three basic configurations: (Figure 7)

- Air/Vacuum Valves
- Air Release Valves

- Combination Valves

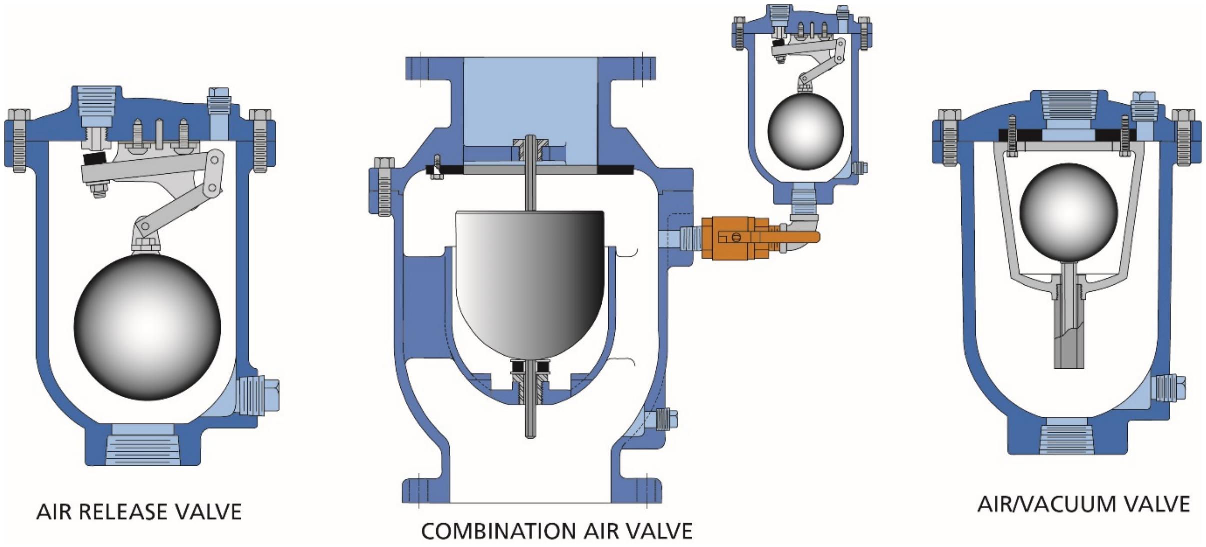

FIGURE 7. Air Valve Configurations

AWWA air valves are constructed of iron or stainless steel bodies with corrosion-resistant trim for water and wastewater service. The correct sizing and location of all three types are critical (Figure 8). Every high point where the pipeline converts from a positive grade to a negative grade should have an air valve. Even minimal high points with small air pockets can cause serious surge problems. In addition, it is recommended that air valves be installed every half mile or 2500 ft. on straight horizontal runs.

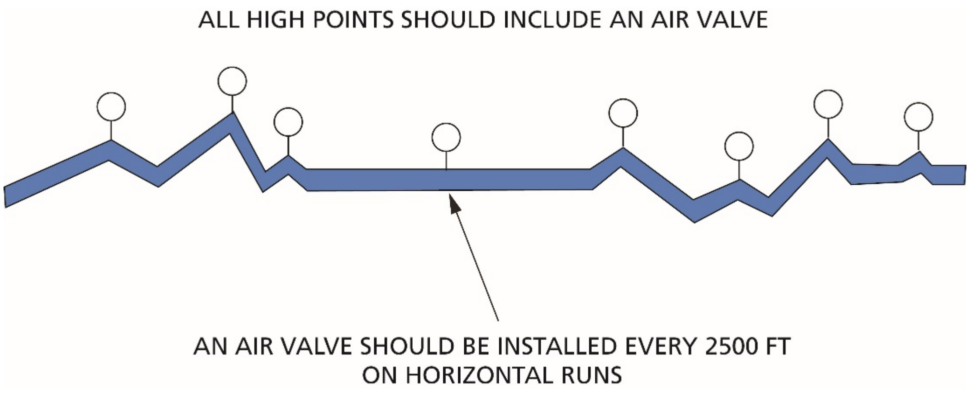

FIGURE 8. Air Valve Placement

Air/Vacuum Valves

Air/Vacuum Valves (Figure 9) have full-size orifices ranging from ½ to 20 in. and are used to exhaust large quantities of air upon system start-up, as well as allowing air to re-enter the line upon system shut down. As water enters the valve, the float will rise, closing the discharge port. The valve will remain closed until system pressure drops to near zero PSI. It will not open and release any accumulation of air while the system is under pressure.

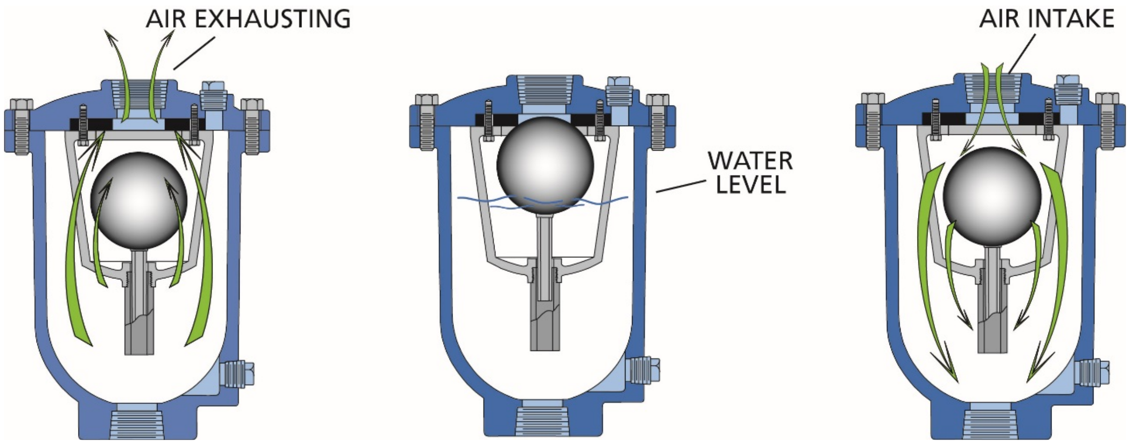

FIGURE 9. Air/Vacuum Valves

An added benefit of an Air/Vacuum Valve is its ability to provide pipeline vacuum protection. If negative pressure develops, the valve will open, admitting air into the line, preventing a possible pipeline collapse or intensified surges.

While Air/Vacuum Valves will exhaust large quantities of air upon start-up, it should be remembered that they will not continuously release air during system operation. For this function, an Air Release Valve is required.

Slow Closing Device (Regulated Exhaust Device)

When an Air/Vacuum Valve is used on vertical pump discharge or on a pipeline where column separation may occur, it is common to include a Slow Closing Device to prevent surges related to air valve slam. The Slow Closing Device automatically closes when high exhaust rates might occur. The device can be mounted on the inlet of a clean water air valve and on the outlet of a wastewater air valve (Figure 10).

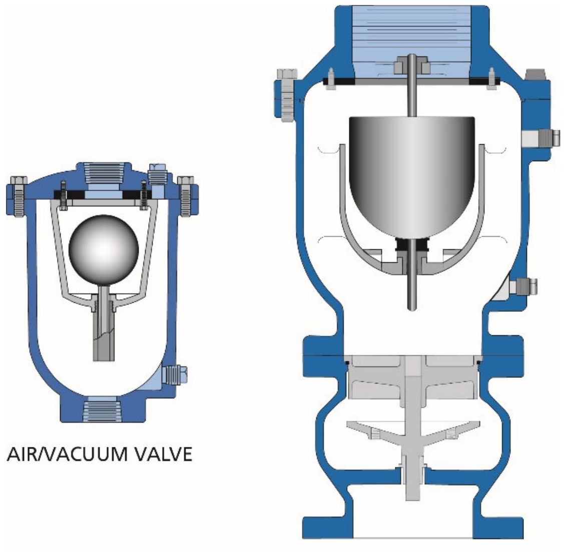

FIGURE 10. Slow Closing Device for Air Valves

Air Release Valves

Unlike an Air/Vacuum Valve, an Air Release Valve (Figure 11) will continuously release accumulated air during system operation. When installed, Air Release Valves are “normally open” and automatically expel air until the valve fills with water. Then, as air from the pipeline enters the valve, it displaces the water, allowing the float to drop. The air is then released to the atmosphere through a small orifice that ranges in diameter from 1/16 of an inch to 1 inch. As the air is vented it is replaced by water, raising the float and closing the valve orifice. As air accumulates, the valve will continue to cycle in this manner to automatically remove collected air.

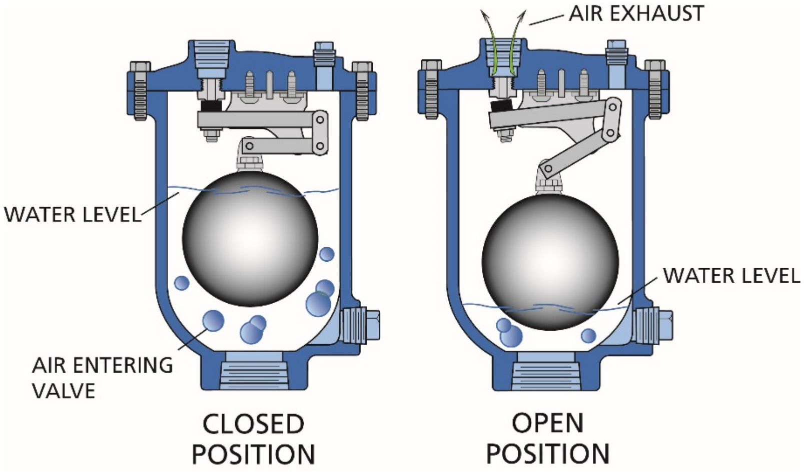

FIGURE 11. Air Release Valve

Combination Air Valves

Combination Valves (Figure 12) perform the functions of an Air/Vacuum Valve (i.e., exhaust large quantities of air on startup, admit air on shut-down) and Air Release Valves (i.e., release air continuously under pressure during operation). Combination Valves are typically available in single body and dual body (an Air/Vacuum Valve and Air Release Valve piped together) configurations. The single body design can be more economical while the dual body design can provide design flexibility when sizing the orifices. Some pipeline designers use only combination air valves on a pipeline because all air valve functions are included; a mistake in field installation will not leave the pipeline unprotected. Other applications for Combination Air Valves include pump discharge headers and upstream of flow measurement devices.

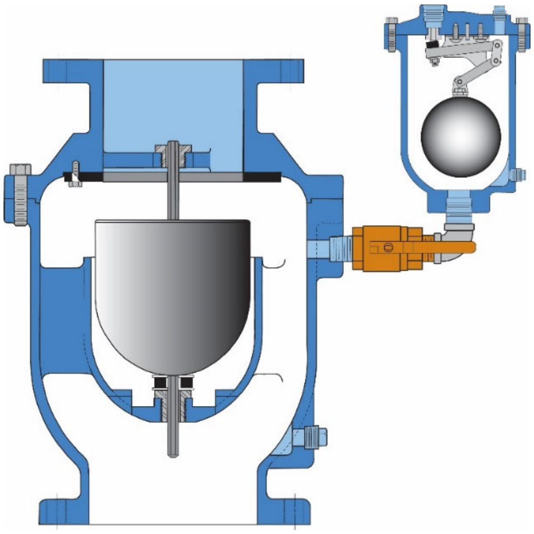

FIGURE 12. Dual Body Combination Air Valve

Summary

When air is allowed to accumulate in pressurized pipelines, efficiency is sacrificed and serious damage can occur. A properly de-aerated pipeline will not solve all surge problems. However, the elimination of air can solve one of their most common causes. Air Valves are a cost effective, reliable method of improving efficiency and solving air related surge problems.

NOTE: Additional copies of Air in Pipelines and the American Water Works Associations' Air Valve Standard C512 are available. An online computer program and a slide rule calculator are available to assist the reader in the correct sizing of air valves. Please contact Val-Matic Corporation for complimentary copies of the papers as well as the calculator.