VAL-MATIC®

# AIR IN PIPELINES

## Sources, System Impact and Removal

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The presence of air in a pipeline and it's 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 line, but by failure to de-aerate the line.

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.

*Additional copies of Air in Pipelines, the American Water Works Associations' Air Valve Standard C512-92, and a paper comparing Air Valves as manufactured by Val-Matic to the Standard's material and design criteria are available. A slide rule calculator is 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.*

## 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 One). This phenomena will occur because air is lighter than water and therefore, will gravitate to the high points. This air will continuously be added to by the second and third sources as the system continues operation.

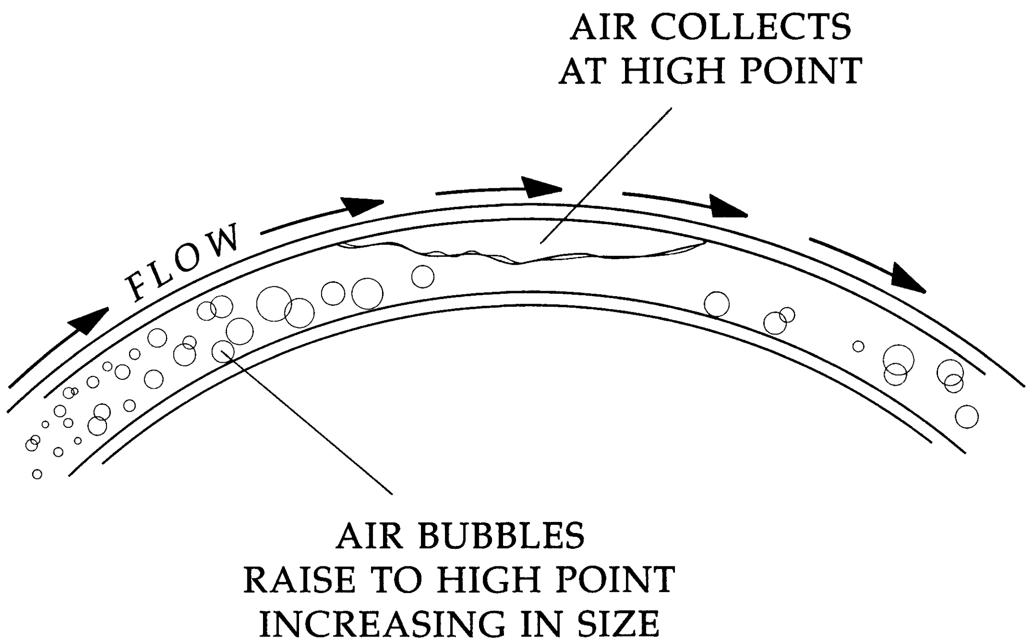



**Figure One**

Source number two is the water itself. Water contains approximately 2% air by volume. During system operation, the entrained air will continuously settle out of 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 slug 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. slug. This would be true regardless of the size of the pipe.

The third source of air is that which enters through mechanical equipment (Figure Two). 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.

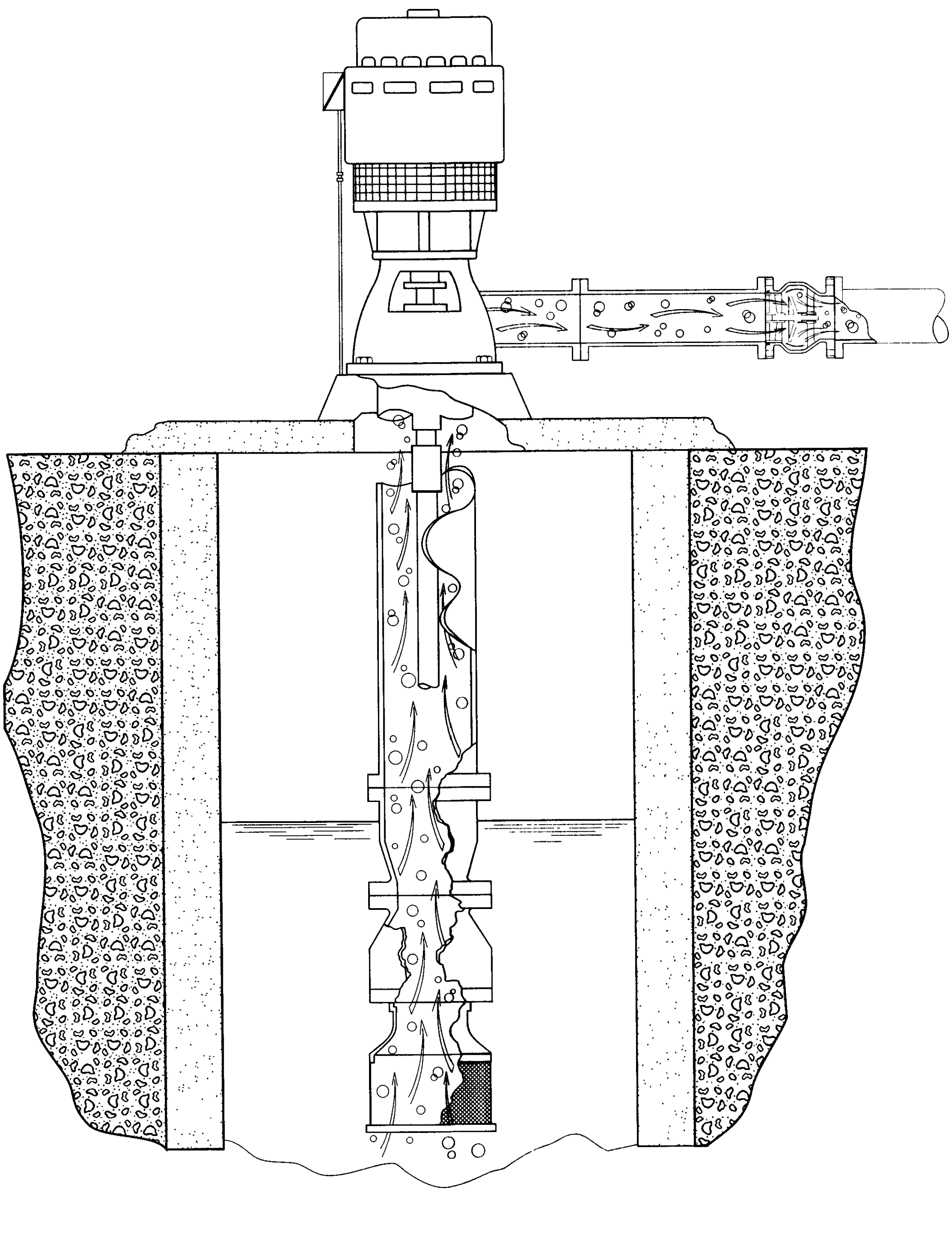


**Figure Two**

## 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 pocket(s) of air accumulating at a high point(s) can result in a line restriction (Figure Three). Like any restriction, the pocket(s) of air increases headloss, extends pumping cycles and increases 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 opening.

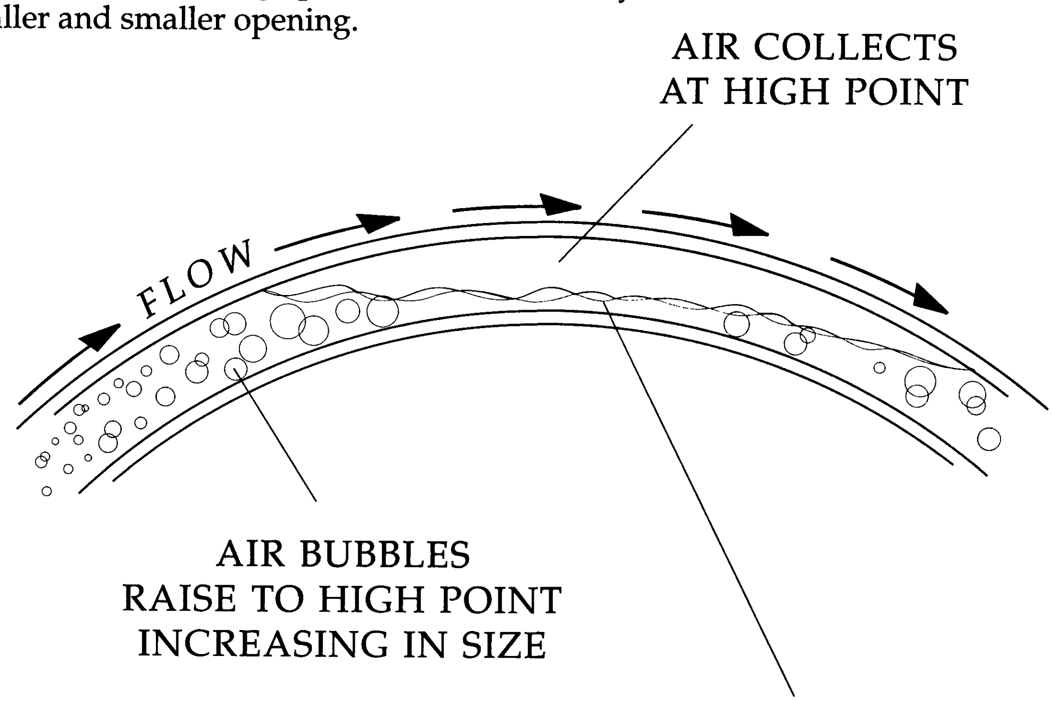



**Figure Three**

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

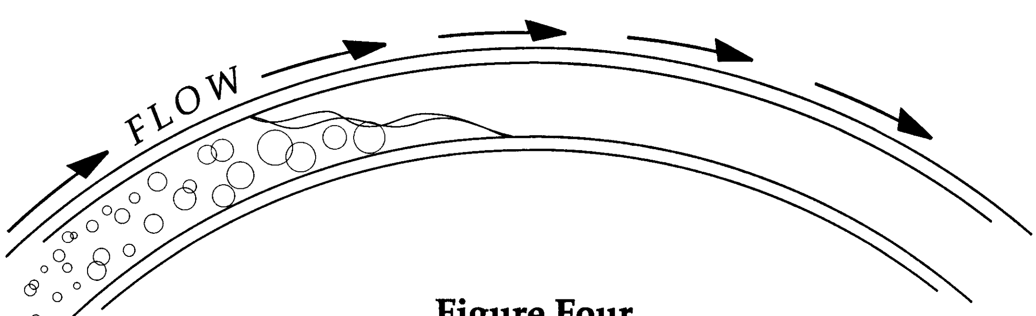



**Figure Four**

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 Five). The sudden and rapid change in fluid velocity when the pocket dislodges and is then stopped by another high point, can, and often will, lead to a high pressure surge (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.

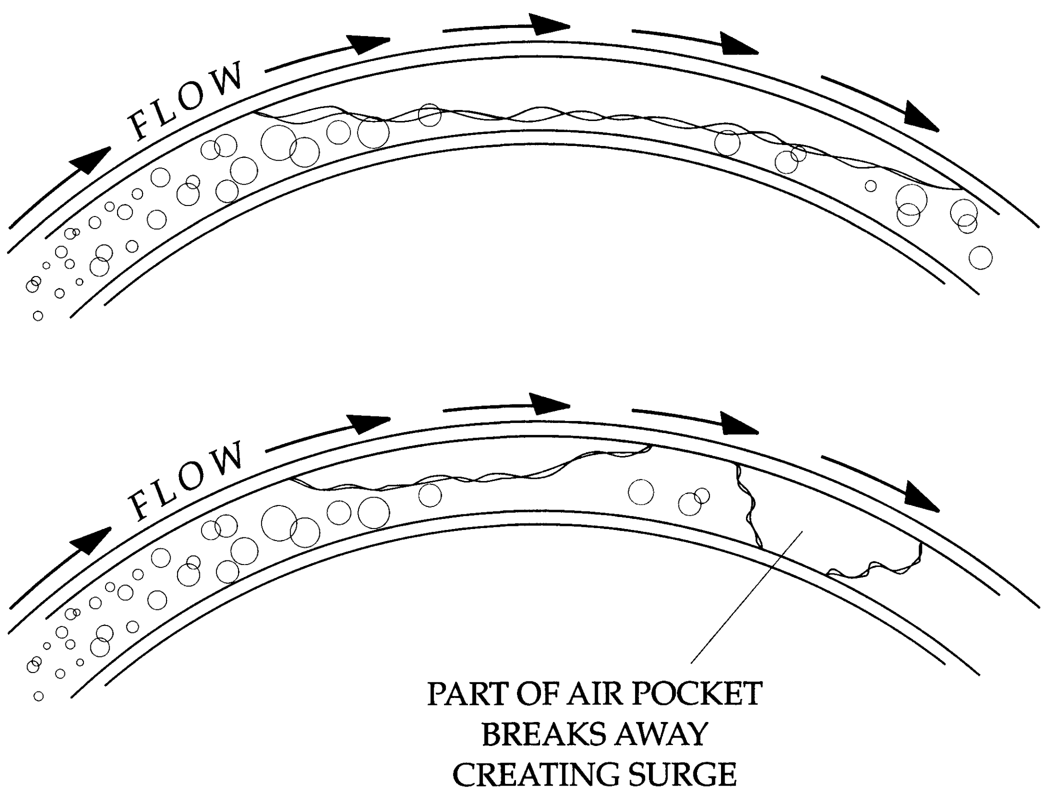



**Figure Five**

As we can see, air in a pressurized pipeline is a serious concern. Obviously, it's removal will result in a more efficient, cost effective operation and potentially avoid more serious problems. In the early 1900's, engineers and water works 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 gate or globe 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 Six) 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!

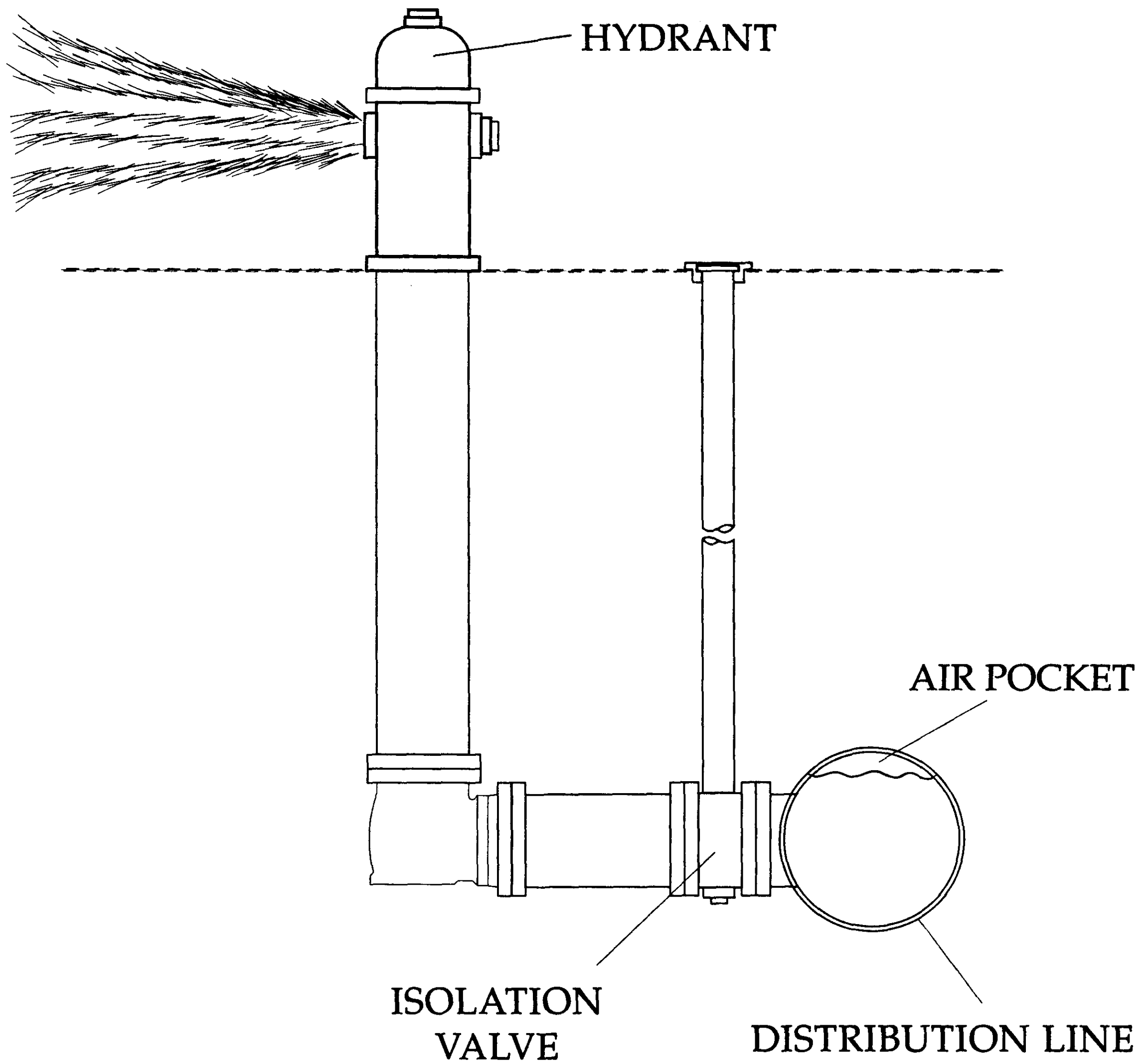



**Figure Six**

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 available in three basic configurations; (Figure Seven) Air/Vacuum Valves, Air Release Valves and Combination Valves.

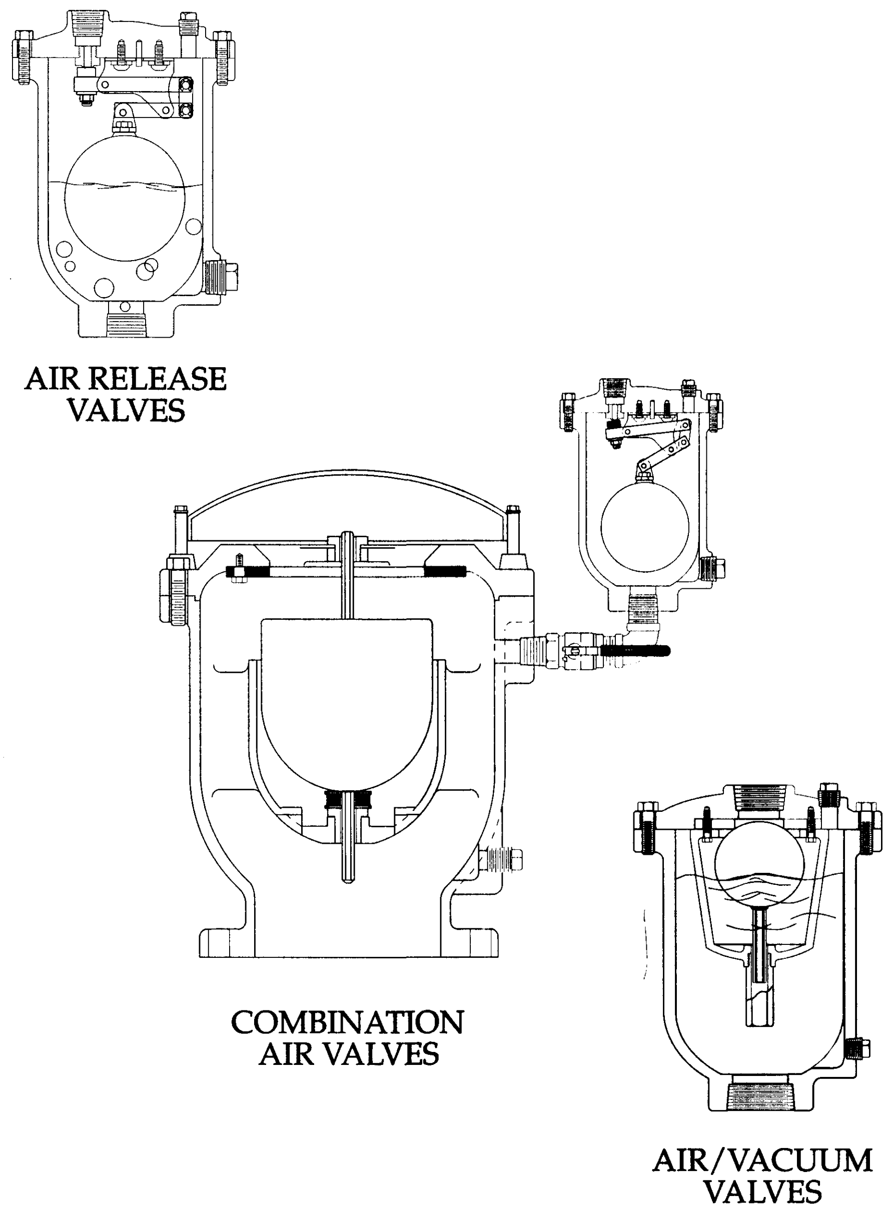



**Figure Seven**

*Correct sizing and location of all three types is critical (Figure Eight).* Every high point where the pipeline converts from a positive grade to a negative grade requires 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 feet on straight horizontal runs.

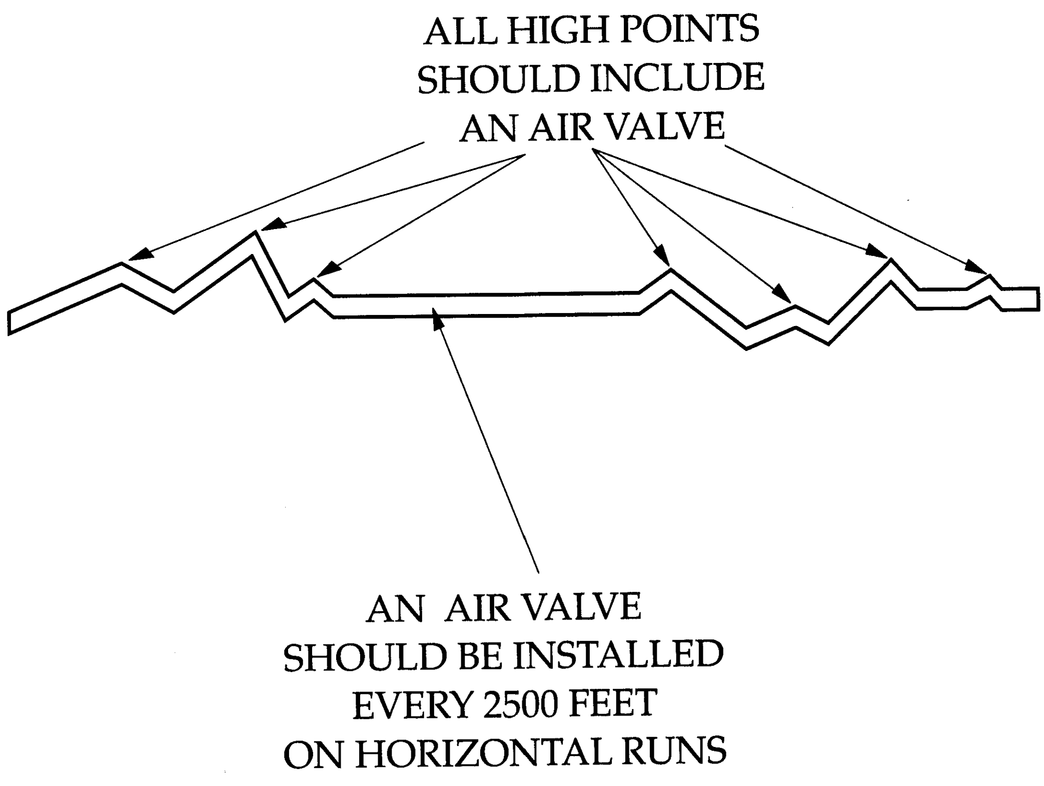



**Figure Eight**

Air/Vacuum Valves (Figure Nine) 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.

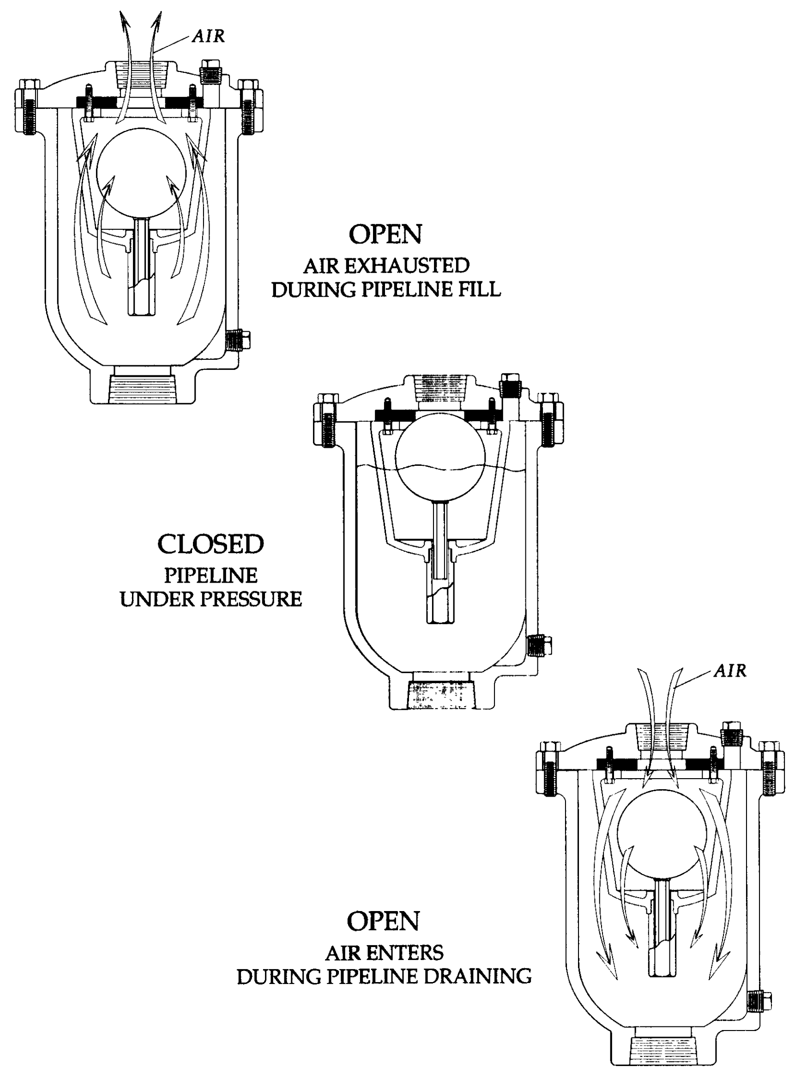



**Figure Nine**

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

Well Service Air Valves (Figure Ten) are a member of the Air/Vacuum Valve family. Turbine pump manufacturers recommend the use of Well Service Air Valves to eliminate the introduction of air into the line by the pump. They are specifically designed to vent air from the pump column upon pump start-up, prior to the check valve opening.

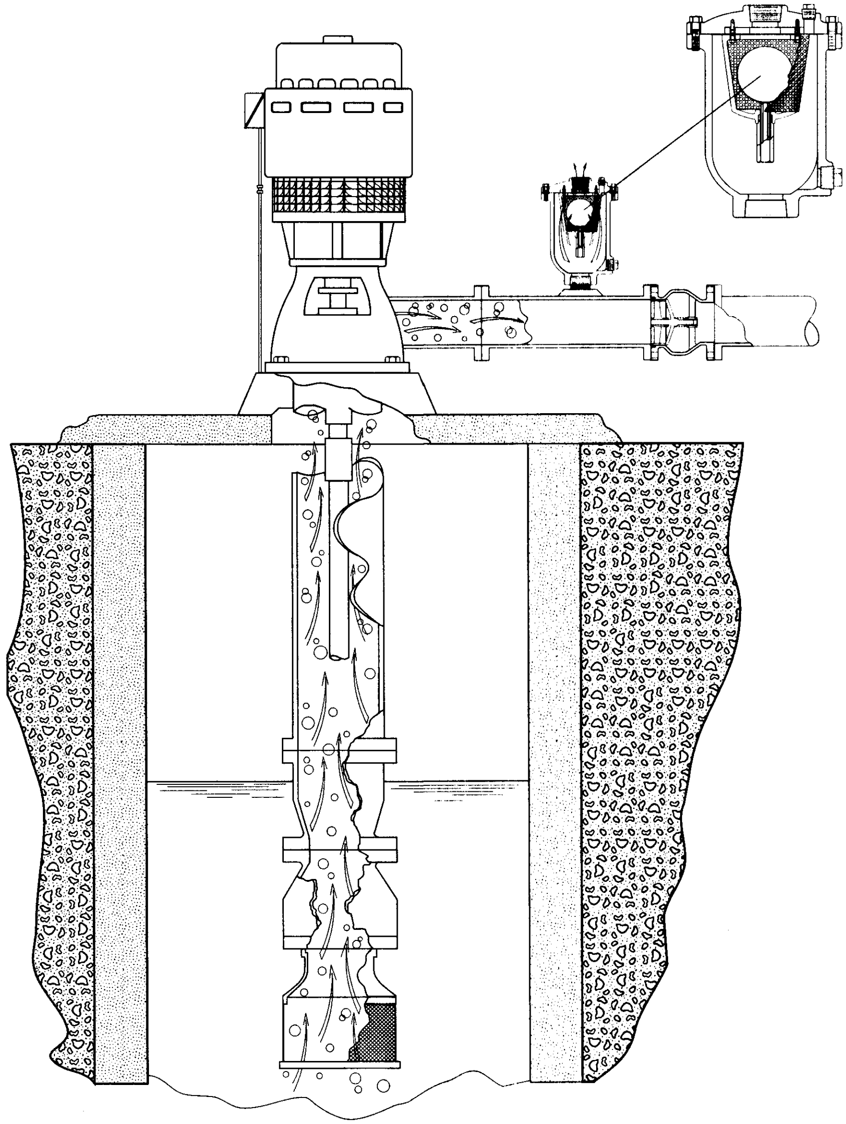
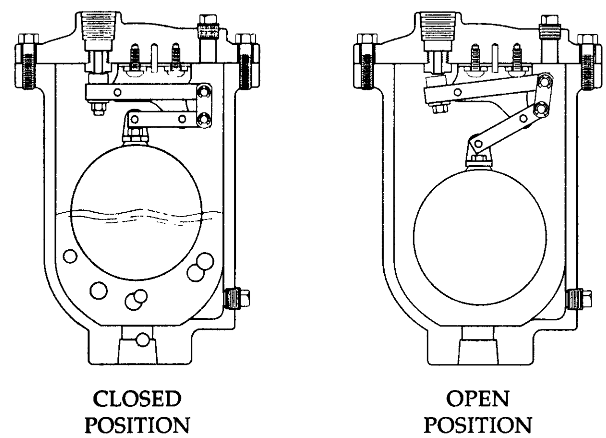


**Figure Ten**

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.

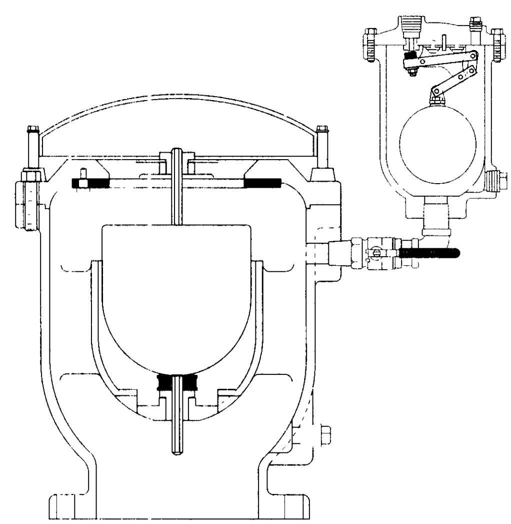
Unlike an Air/Vacuum Valve, an Air Release Valve (Figure Eleven) will continuously release accumulated air during system operation. As air from the pipeline enters the valve, it displaces the water, allowing the float to drop. The air is then released to atmosphere through a small orifice. As the air 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 remove collected air.

**Figure Eleven**




Combination Valves (Figure Twelve) perform the functions of an Air/Vacuum Valve (exhaust large quantities of air on start-up, admit air on shut-down) and Air Release Valves (release air continuously during operation). Combination Valves are typically available in single body and dual body (an Air/Vacuum Valve and Air Release Valve piped together) configurations.

**Figure Twelve**



To summarize, 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.