

Reduction of Damage and Hindrance to Wastewater Transmission Systems Caused by Air Pockets by Deployment of Air Valves

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Abstract

Recent research studies and surveys have shown that air pockets in wastewater transmission systems cause extensive damage and hindrance. Air pockets decrease flow capacity, they induce significant head losses and energy losses, they prompt serious corrosion, and they can trigger and/or enhance pressure surges.

In the advent of concern for energy conservation, more and more research is invested in studying the effect of air pockets on flow efficiency and energy consumption. Conclusions are that air pockets have a very significant impact on these, especially in wastewater force mains.

Much has been written in the past about Hydrogen Sulfide corrosion in wastewater pipelines. The EPA published a number of papers, pamphlets, and reports to Congress on this subject. More and more papers and studies today, attribute Hydrogen Sulfide corrosion to air pockets, including a number of papers presented at the ASCE Pipelines 2009 Conference in San Diego. Most of these papers refer to detection, monitoring, evaluation, assessment and management of corrosion, but not of prevention. They point out the contribution of air pockets to Hydrogen Sulfide corrosion, but they do not discuss the means and ways of preventing air pocket accumulation.

Though, for many years, it was commonly accepted by surge experts that air pockets dampen surges, it was determined in recent research studies that air pockets of certain sizes and in certain locations along a pipeline, can induce and/or enhance surges. These surges, especially in force mains weakened by corrosion, can cause intensive and severe damage to pipelines, resulting in soil and water source polluting leakage, and health endangering pathogen and contaminant intrusion to drinking water transmission systems.

Even though there is a great mistrust of air valves for wastewater applications, modern, innovative air valves are reliable and efficient, and are an extremely cost efficient and readily available device for preventing the accumulation of air pockets and for averting the above-mentioned damages and hindrances.

Air entrainment in pipelines

Air can enter pipelines in many different ways. When a pipeline is “empty” it is actually full of air. In order to fill the pipeline with water, we must discharge the air. But, because the pipeline profile is often undulating, air is often entrapped at locations along the pipeline during pipe filling, usually at peaks, but not only.

When pressure in locations along the pipeline falls below atmospheric pressure (at water column separation due to pump stoppage, for instance), air can be sucked into the pipeline at above-surface pipe sections, through faulty joints, past poorly positioned seals and gaskets, through pipe accessories, through air valves, through cracks, or through other gaps in the pipeline.

Air entrainment is much greater in wastewater force main systems than in other pumped liquid transmission systems because of their unique design and operational characteristics. Lift stations with wet wells or other sewage collection basins are a major source of entrained air, induced by plunging jets of sewage and by vortices of air sucked into the pump (see Figure 1). Due to the cyclic operation of force main systems, sections of the force mains empty out at the end of each pumping cycle, drawing air into the pipes. In drop manholes at the beginning of charged pipeline sections, air is entrained due to plunging jets of sewage.



Figure 1: A plunging jet of wastewater into a wet well, entraining air at the pumps' intake

The solubility of air and other gases in water, or the capacity of water to hold air/gases in solution, changes with change in temperature and/or pressure. As pressure drops and as temperature rises dissolved air and gases come out of solution. As water is driven through a pump, it warms up. As water flows in the pipeline, it warms up further due to resistance, and if the environment around the pipe is warmer than the water in the pipe, it warms even further. As water in the pipe warms up, dissolved air is released from the water.

A pump raises the pressure head at the pump station to enable water to flow downstream, overcoming resistance, head losses, and increases in elevation. For this reason, pressure at the pump station is usually higher than in much of the downstream pipeline. As pressure drops downstream from the pump, more dissolved air is released. Turbulence in the pump and along the pipeline and phenomena such as hydraulic jumps, also result in release of dissolved air and gases.

Air and gases are released in the form of very fine bubbles entrained in the water flow. In down-sloping and level pipeline sections, a minimum water flow velocity is required for transporting these fine bubbles with the water stream. This critical velocity for transporting air/gas bubbles depends on the size, shape, and concentration of the bubbles and on the down-slope and diameter of the pipe. The critical velocity usually increases with increase in bubble size, in down-slope and in pipe diameter (Escarameia et. al., 2005)⁽¹⁾. In pipeline system design, pipe diameter is determined according to peak flows at some future peak demand. As direct consequence of this, there is often a period at the initial operation of a new pipeline, when pipe sections may be over designed and flows are low. There are always periods in the 24-hour-day when demand is minimal (such as in the late-night, early-morning hours) and flows are below critical velocity. In these periods of low velocity, entrained air/gas bubbles combine to form air/gas pockets at peaks, at the crown of the pipe, at in-line and on-line fittings and accessories, and at other locations along the pipeline. These entrained air/gas (air) pockets often grow to sizes that even fast-flowing water cannot carry downstream. These air pockets can break down to smaller air pockets and be spread downstream to form elongated air pockets at the crown of the pipe (see Figure 2).

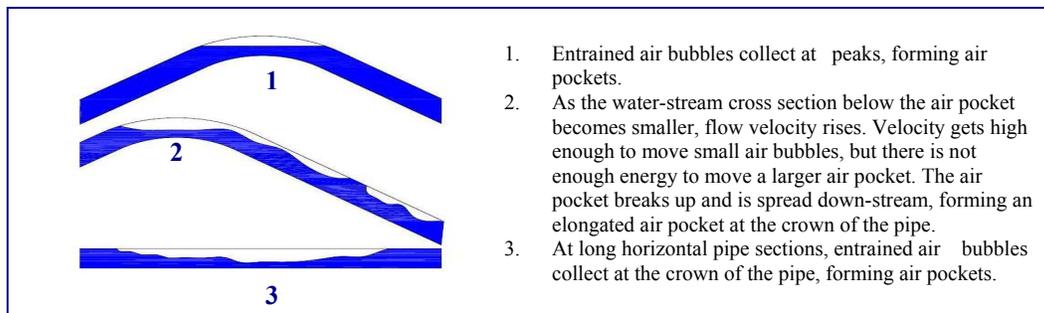


Figure 2: Accumulation of entrained air bubbles into air pockets – some simplified examples.

Head losses, decreased flow capacity, and increased energy consumption due to entrained air

As can be seen in Figure 2, as the size of air pockets increase, the cross sectional area of the water stream below them decreases. In pipe sections where water stream area is reduced, resistance increases, resulting in increased head losses. Increased head losses result in decreased flow capacity and in increased energy consumption.

But, often, when flow velocity is above critical velocity, entrained air bubbles and air pockets in operational pressure mains and force mains are not stationary and do not

remain uniform in size and shape. Quite often, they are very dynamic. They break up and they combine, they change shape, they move and sometimes change the direction of movement. Pressure and temperature effect air bubble/pocket size. They expand at increased temperature and contract as temperature drops. They expand at decreased pressure and compress at increased pressure.

Two phase Air/water flow is usually characterized in distinct flow patterns, such as *Bubble Flow*, *Plug Flow*, *Stratified Smooth Flow*, *Stratified Wavy Flow*, *Annular Flow*, and *Spray Flow*. Each flow pattern has its special features and effects on the water flow (Escarameia, 2005)⁽²⁾.

There are three major factors that influence entrained air behavior in pipelines: Buoyancy, Drag, and Equilibrium in surface tension (water/air/pipe wall). These factors, together with air pocket size and concentration, influence the tendency of bubbles to aggregate and grow larger and determine the direction of their movement - with or opposite to the direction of water flow (Lubbers and Clemens, 2005)⁽³⁾. These also affect the entrained air pockets' influence on water flow capacity, on head losses, and on energy consumption. In rising pipe sections and when there is no flow in the pipeline, buoyancy will force air pockets of all sizes and shapes to travel to peaks along the pipeline. At down-sloping and level pipe sections, when buoyancy exceeds drag, air pockets will travel upward, in opposite direction of the flow. When drag exceeds buoyancy, air pockets will travel in the direction of flow. Large air pockets traveling in opposite direction to the water flow due to buoyancy often break up to smaller pockets, resulting in smaller pockets and bubbles changing direction and

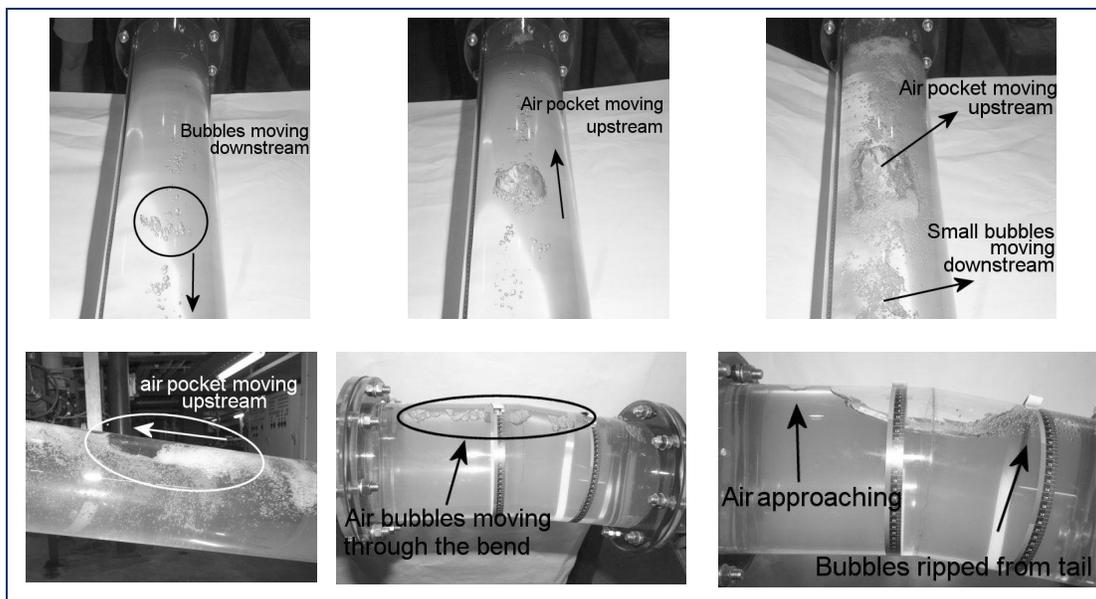


Figure 3: Air bubble and air pocket behavior in a down-sloping pipe section and at a bend (Lubbers and Clemens, 2005 with permission from Lubbers and Clemens)⁽³⁾.

being dragged with the water stream, and larger pockets continuing to travel upstream. Air pockets traveling with the water stream also often break up into smaller pockets and bubbles that disperse in the water stream, traveling in different velocities (see Figure 3). In all these cases, air pocket movement disturbs the flow, where drag and turbulence increased head losses, resulting in decreased flow capacity and in increased energy consumption (Lubbers and Clemens, 2005)⁽³⁾.

In his paper: “*Investigation on the Effects of Entrained Air in Pipelines*”, Oscar Pozos-Estrada writes: “Investigations on a variety of water pipelines throughout the world have revealed that entrapped air can reduce their efficiency by as much as 30%. Most pipeline systems are commonly operated with air contents that diminish system flow efficiencies by 15 to 20%. Pockets of compressed air present enormous obstacles to any efforts to pump fluids. Entrapped air increases head pressure by 20% and will force pumps to perform 20% harder, and thus demand 20% more electrical energy to overcome the restrictions” (Pozos-Estrada, 2007)⁽⁴⁾.

M. Escarameia et. al., in the paper: “*Experimental and Numerical Studies on Movement of Air in Water Pipelines*” state that: “Although limited reliable data was collected, the test results appear to show that, for the same flow conditions, the hydraulic gradient associated with flow with an air pocket is 25 to 35% bigger than associated with water alone” (Escarameia et. al., 2005)⁽¹⁾.

Other researchers and experts point out the negative effect of entrained air on flow capacity and efficiency without quoting specific numbers. Lubbers and Clemens, for instance, in their paper: “*Capacity Reduction Caused by Air Intake at Wastewater Pumping Stations*” point out that: “Free gas in pressurized pipelines/mains can significantly reduce flow capacity. When the capacity of wastewater pressure mains fails to be in line with the design value, undesirable spills or efficiency loss may be the result” (Lubbers and Clemens, 2005)⁽³⁾.

A.R.I. is presently in the midst of a survey of lift stations throughout North America, relating to energy consumption effected by entrained air, and preliminary results point out extremely significant effects.

Internal corrosion in pipelines attributed to air pockets

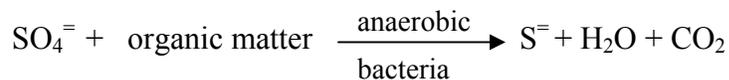
Water and wastewater often contain dissolved oxidants, such as oxygen and chlorine. When in contact with metallic iron, these oxidants present a driving force for active corrosion. It is claimed that corrosion rate is probably limited by the rate at which oxygen (that comes out of solution) is provided to the surface (American Water Works Services, 2002)⁽⁵⁾. Oxidation that usually appears in the form of rust is the most common type of corrosion in water systems. In the oxidation process, electrons are exchanged between the metal and free oxygen in the environment adjacent to the metal (EPA, 1985)⁽⁶⁾. Entrained air pockets are a major source of oxygen and major contributors to this type of corrosion.

In wastewater systems in particular, the prevailing process contributing to massive internal corrosion is probably the process referred to as Hydrogen Sulfide Corrosion. Hydrogen sulfide corrosion is a major cause for wastewater transmission pipe damage and deterioration. This biochemical process is often thought to affect only gravity sewers and pipelines that are not surcharged. But, force mains, inverted siphons, and other surcharged wastewater pipelines, and sometimes even very long pressurized water pipelines carrying water with low dissolved oxygen concentration and high sulfur concentration, are susceptible to hydrogen sulfide corrosion in places where air pockets accumulate. Air pockets accumulate mostly at high points and at the crown of the pipe, creating conditions similar to partial pipe flow.

The United States EPA, concerned with the problems of hydrogen sulfide corrosion, sponsored a number of research studies on the subject. In a report of one of these studies, entitled “*Detection, Control, and Correction of Hydrogen Sulfide Corrosion in Existing Wastewater Systems*”, it is written that: “Since the pipes are generally full of wastewater, corrosion will not occur within surcharged pipes unless they contain air pockets. If an air pocket exists, corrosion may occur very quickly” (Bowker et. al., 1992)⁽⁷⁾. Pipes of almost all materials, other than plastic materials, are susceptible to hydrogen sulfide corrosion. These include steel pipes, cast and ductile iron pipes, concrete pipes, cement or mortar lined steel and iron pipes, asbestos cement pipes, and more.

The biochemical processes generating the hydrogen sulfide corrosion process can be generally summarized thus:

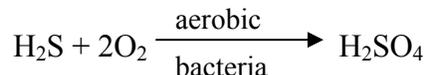
1. When oxygen concentration in the wastewater flowing in the pipeline drops very low, below about 0.1 mg/l, an anaerobic slime layer develops on the wetted surface of the pipe wall. Anaerobic bacteria in the slime layer reduce sulfate that originated in the wastewater to sulfide.



2. Sulfide is released from the slime to the wastewater and forms hydrogen sulfide, H₂S, which is released to the air pocket above the liquid.



3. Moisture from condensate covers the pipe wall at the crown of the pipe and above the water level where aerobic bacteria thrive. H₂S in the entrained air pocket is oxidized by the aerobic bacteria, mostly of the genus *Thiobacillus*, to sulfuric acid.



4. The sulfuric acid attacks the non-submerged pipe wall, causing corrosion. In reinforced concrete pipe and in mortar or concrete lined metal pipes, the sulfuric acid eats away the concrete or lining, exposing the metal reinforcing or the metal pipe wall to further attack by the sulfuric acid.

H₂S gas in the air pocket above the water level also attacks metal surfaces directly, causing corrosion. (EPA, 1991)⁽⁸⁾

Corrosion, mostly hydrogen sulfide corrosion, causes havoc in wastewater systems all over the world, resulting in dangerous polluting and contaminating leakage and spills. This raises concern of many environmental and professional organizations around the world, such as the IWA, AWWA, EPA, WEF, ASCE, and others. In its general concern for the condition of infrastructure in the United States, the American Society of Civil Engineers, ASCE, keeps track on the condition of infrastructures and publishes a constantly updated “*Report Card for America’s Infrastructure*” on the internet, at: <http://www.infrastructurereportcard.org/>, and in published reports. The “Report Card” covers 15 different Infrastructure subjects, including drinking water infrastructure and wastewater infrastructure. Since 2005, the grade awarded by the ASCE to both, drinking water and wastewater infrastructure, was D-. The 2005 report included a review of the condition of each of the 15 infrastructures in the United States and a specific review that discussed the “Top Three Infrastructure Concerns” out of the 15 different infrastructures, for each of the states and the District of Columbia. For 25 states wastewater infrastructure was listed as one of the top three infrastructure concerns, for 5 states drinking water infrastructure was listed as one of the top three infrastructure concerns, and in one state drinking water infrastructure and wastewater infrastructure were listed as two of the top three infrastructure concerns (ASCE 2005)⁽⁹⁾.

ASCE’s Pipelines2009 Conference in San Diego in August 2009 was devoted to “Infrastructure’s Hidden Assets”. Many of the papers presented at the conference dealt with the problems of internal pipeline corrosion, mostly hydrogen sulfide corrosion, and most attributed corrosion to the presence of air pockets in the pipes. In their paper titled: “*Economic Considerations of Corrosion Control Strategies for Water and Wastewater Transmission Pipelines*”, R.L. Bianchetti and C. Perry cite a study conducted for the U.S. Federal Highway Administration (FHWA) and released in 2002, that estimated the direct cost of corrosion in the U.S. to be \$276 billion, of which \$39 billion were attributed to the water and wastewater sector (Bianchetti and Perry, 2009)⁽¹⁰⁾.

Bell, Pilko, and Pannell, in their paper: “*Managing and Monitoring Corrosion on Ductile Iron Pipe Force Mains*”, discuss the very serious problems of internal hydrogen sulfide corrosion in ductile iron force mains experienced in the Orange County Sanitation District in Southern California, and of ways taken to manage and monitor this corrosion. The authors cite the contribution of air pockets to the problems, stating: “Unfortunately, pipelines in the constructed environment can develop air pockets at high points in the line which leads to corrosion in and around the air pocket”. They elaborate on the subject adding: “Air pockets in ductile iron pipe (DIP) force mains (FM) can be problematic if internal linings are compromised. Formation of sulfuric acid in the humid air space at the crown of the pipe can cause rapid corrosion of the iron leading to uncontrolled discharges (Bell, Pilko, and Pannell, 2009)⁽¹¹⁾

In another paper presented at Pipelines 2009, Martha Santana and Edward Padewski discuss fears of possible future failures in a 72-inch to 120-inch effluent pipeline constructed in the 70's and 80's in Puerto Rico using prestressed concrete cylinder pipe (PCCP). The fears stemmed from serious failures experienced on similar PCCP pipelines in the jurisdiction of the Puerto Rico Aqueduct and Sewer Authority (PRASA). Again, citing the link between air pockets and hydrogen sulfide corrosion, the authors write: "Under certain conditions, hydrogen sulfide gas may accumulate in air pockets that form at high points in wastewater force mains. The gas can oxidize into sulfuric acid and damage the top of the pipe wall. Conversion of the gas to sulfuric acid requires an aerobic or oxygen-supplied condition – such as that provided by an air pocket." The paper discusses different tests performed to determine present and possible future conditions of the pipes and in the recommendations at the end of the paper the authors include suggestions to repair and maintain faulty air valves to ensure release of aggressive gases, and to perform leak and air pocket detection surveys in order to locate air pockets in the lines since "Such pockets may be generating the conditions necessary for hydrogen sulfide corrosion." (Santana and Padewski, 2009)⁽¹²⁾

Kenneth and Karl Kienow, in their paper *"Most Pipeline Failures Can be Prevented by Proper Inspection"*, report on "failure due to sewage sulfide/H₂S/H₂SO₄ induced acid attack" in asbestos cement pipes (ACP) and in reinforced concrete pipes (RCP) as well as in DIP and PCCP pipes. They mention the fact that "A full pipe will not be subject to sulfide induced acid corrosion of the pipe wall", they discuss the use of air valves, and claim that: "...the failures always occur at or near high points (Kienow and Kienow, 2009)⁽¹³⁾.

The above papers describe in great detail the problems and the causes of the problems (air pockets and the hydrogen sulfide corrosion process), they discuss evaluation, assessment, detection, inspection, monitoring, and managing of corrosion in pipelines. They describe monitoring pipe wall degradation (thinning) by corrosion in order to determine pipeline replacement priorities. But they do not discuss proactive solutions for the prevention of air pocket formation and/or for exhausting air and gas from the pipeline.

Neal Stubblefield, et. al., presented a very comprehensive and thorough condition assessment of a 14.1 mile long regional force main (RFM) at the WEF Collection Systems 2009 conference in Louisville, Kentucky, titled: *"A "Swiss Knife" Approach: Condition Based Assessment of a South Florida Sewage Force Main"*. This RFM, under shared ownership and operation by the City of Lake Worth and Palm Beach County, FL, was installed in 1972-79 and includes a 36" PCCP section and a 42" – 54" DIP section, and serves six additional municipalities and over 475,000 residents. The paper describes in details the condition and operation of the force main in the past and in the present, section by section, its failures and repairs, including results of different comprehensive tests and surveys that appraise the pipelines themselves and other components of the system, such as pump stations and

air valves. Like some of the other papers mentioned, this paper discusses the deterioration of the crown of pipes, the extensive internal corrosion, the hydrogen sulfide corrosion process and air pockets, etc. In addition to degradation and attack by sulfuric acid, this paper discusses severe corrosion resulting from direct long exposure to H₂S levels exceeding 100 ppm by volume on bare metal. The paper states the importance of the pipelines to flow full, without air pockets. Most notably, this paper discusses the vital importance of functional and efficient air valves for keeping force mains flowing full and without destructive air pockets. The authors even recommend the use of advanced, innovative air valves that are more reliable than the commonly used traditional air valves (Stubblefield, et. al., 2009)⁽¹⁴⁾.

Air/gas pockets and pressure transients

Though, for many years, it was commonly accepted by surge experts that air pockets dampen surges, it was determined in recent research studies that air pockets of certain sizes and in certain locations along a pipeline, can induce and/or enhance surges. These surges, especially in force mains weakened by corrosion, can cause intensive and severe damage to pipelines, resulting in soil and water source polluting leakage, and health endangering pathogen and contaminant intrusion to drinking water transmission systems.

A.R.D. Thorley, in his book, *“Fluid Transients in Pipeline Systems”*, states that: “extremely high shock loads can be generated when moving slugs of liquid following pockets of gas suddenly encounter valves, pipe bends and similar obstructions to the flow” (Thorley, 1991)⁽¹⁵⁾. In the publication, *“Air problems in pipelines – A design manual”*, it is pointed out that several investigators reported that peak transient pressures can be larger in pipes with air pockets (which are referred to as air-filled voids), than in pipes without air pockets. It is also stated that: “In the absence of air valves on the summits of undulating pipeline profiles, the presence of air pockets, even if migratory, is inevitable, with potential impact on resulting surge.” The publication indicates that pressure magnifications in factors as high as 2.6 and even 9, have been observed by researchers (Escarameia, 2005)⁽²⁾.

R. Burrows and D.Q. Qiu, in their article, *“Effects of air pockets on pipeline surge pressure”*, demonstrate through a series of analytical examples, the diverse effect air pockets can have on surge events in pipelines not protected by surge suppressing devices. Pressure intensification as high as 1.6 or even 2 times normal operational pressure, which could lead to possible catastrophic effects, was predicted. The authors conclude that whereas large air pockets acting as accumulators can suppress extreme pressure deviations - following pump shut-down, for instance, it seems that multiple small pockets resulting from large pocket break up can significantly intensify peak pressures. The presence of a small air pocket (< 0.5 m³ in the examples demonstrated) is a cause for significant amplification of peak pressure. “The degree of peak pressure enhancement has been shown to depend on both the position of the air pocket in the pipeline and the location along the pipeline which is under scrutiny” (Burrows and Qiu, 1995)⁽¹⁶⁾.

O. Pozos-Estrada, in his paper, *“Investigation on the Effects of Entrained Air in Pipelines”*, also shows that small air pockets cause a considerable increase in the intensity of transients, both, positive and negative. In one example of surge analyses of transients caused by power failure at a three-pump pump station, there are 4 air pockets positioned at four points on the pipeline profile. Four analyses were run – one with no air pockets, and three with small, large, and intermediate size air pockets. The small air pockets very clearly resulted in both, the highest upsurges, and highest down-surges (Pozos-Estrada, 2007)⁽⁴⁾.

In their comprehensive report on studies of air in pipelines, *“Experimental and numerical studies on movement of air in water pipelines”*, M. Escarameia and her colleagues list a number of observations and conclusions regarding amplification affects of air pockets on pressure transients, among them; a) that small air pockets have the potential to enhance the frequency and amplitudes of pressure waves; b) that air pockets at the upstream section of a pipe and close to the pump have a greater potential for destructive enhancement of pressures; c) that smaller air pockets produce higher pressures at upstream junctions on the pipeline, and larger air pockets produce higher pressures at downstream junctions on the pipeline, depending on the pipeline configuration; d) that there is a limit to the size of a small air pocket that enhance pressure peaks – a ‘critical’ size; e) that in certain pipe small air pockets produce peak pressures along the majority of the pipeline and also result in cavitation along part of the pipeline profile; f) that in certain pipe profiles larger air pockets enhance peak pressures along sections of the pipeline; and g) that the ‘critical’ size of an air pocket depends on the pipeline configuration and air pocket location on the pipeline – in the examples presented = 0.05 m³ – 0.10 m³ (1.77 ft³-3.53 ft³). One very important conclusion of this study determines that: “The presence of air pockets have been shown, in certain circumstances to cause both high and low pressure fluctuations which are sufficiently large to potentially cause pipe fracture and pipeline failure. This therefore highlights a need for consideration of the transient wave interaction with entrapped air pockets during design stage” (Escarameia et. al., 2005)⁽¹⁾.

Mistrust of air valves and modern solutions

Though most water/wastewater engineers aware of the importance of air valves in expelling air from charged water and wastewater systems and for preventing the accumulation of entrained air pockets in pipelines, some of them are of the opinion that automatic (non-manual) air valves, especially in wastewater systems, are not reliable and should not be used. These fears may have been plausible years ago, when automatic air valves were less reliable, but today, more advanced and innovative automatic (non-manual) air valves that are fully dependable and efficient are readily available.

Mistrust and uncertainty relating to wastewater air valves are even more widespread than for water air valves, due to the very difficult operational environments and conditions under which wastewater air valves are required to function. Traditional automatic (non-manual) wastewater air valves, that were improved very little in past decades, have an extremely poor operational record.

George Tchobanoglous, in his Metcalf & Eddy textbook, *“Wastewater Engineering: Collection and Pumping of Wastewater”*, in pages 388-389, expresses his mistrust of non-manual wastewater air release valves and air/vacuum valves, stating that Automatic air-release valves and air and vacuum valves should not be installed if their use can be avoided. His reasoning for this is that they require frequent maintenance and their malfunction could create water hammer problems. He recommends using manual air valves (taps) and that the problem of possible collapse of force main pipes “should be solved by the use of pipe having walls sufficiently strong to withstand the induced added crushing load” (Tchobanoglous, 1981)⁽¹⁷⁾. Here, the author considers only pipe integrity, disregarding other probable damages and dangers of down-surges.

There were some very advanced, far-reaching changes in the design of wastewater air valves that make these advanced, modern air valves dependable, efficient, and simply and effectively maintained. Modern, cutting-edge wastewater air valves are available with body shapes and textures that resist buildup and clogging, in a variety of body materials, plastic and metal, including reinforced nylon and stainless steel, and with a wide range of special coatings, inside and out, all of which enable dependable, corrosion and damage free use in almost any application.

Some of the special features of these modern air valves are:

- A conical body with a large midriff that ensures plenty of room for the float to move freely and not be captured in grease, that makes it more difficult for the valve to be clogged up in grease, that enables a much larger initial air pocket at valve closure that is compressed in the horizontal as well as in the vertical direction as pressure rises, thus preventing a rise in the water level inside the valve that endangers the sealing mechanism from clogging or leakage.
- Outward-slanting valve walls impede accumulation of grease on the walls, and the funnel shaped bottom guides grease and solid matter back into the force main after each pumping cycle.
- A freely moving float.
- A rolling seal that allows a much larger air release orifice and ensures efficient sealing even at backpressure as low as 3 psi, and simple a sealing mechanism without internal levers, hinges, and pins that can be extremely problematic because they are convenient traps for hair, rags, and a multitude of other objects to be caught on, and are very susceptible to corrosion and wear.
- A very light body that is very easily dismantled for maintenance and servicing, and more.

There is an assortment of wastewater air valve models available which was never available before. Today, innovative subsurface water and wastewater air valves, complete with their integral under-ground valve box, can be fully serviced and disconnected from ground level, and are readily available (A.R.I., 2010)⁽¹⁸⁾



Figure 4: Stainless steel and composite material combination air valve for wastewater

Another reason for distrust of traditional air valves for water and wastewater is related to pressure transients. It is claimed that air valves cause slam and upsurge at closure that can affect the integrity of the system. Today, there are integral non-slam accessories available for modern wastewater air valves that enable efficient operation without the fear of causing slam and/or local surges at valve closure. For clean water, a new, revolutionary, dynamic combination air valve, utilizing a hydraulically piloted diaphragm instead of a float, completely eliminates local surges formerly attributed to air valves.

Conclusion

In order to ensure efficient and safe wastewater transmission while limiting energy consumption, avoiding and preventing destructive internal corrosion, and protecting the system from disruptive and/or destructive air pocket induced pressure spikes, air bubbles and air pockets should be removed from force mains and other surcharged wastewater mains.

Modern, innovative, dependable wastewater air valves, when correctly designed, sized, located, specified, and installed, are the most cost effective tools to control air and entrained air bubbles and air pockets in pressurized wastewater transmission systems.

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