Innovative Valves for Liquid Transmission Applications

A.R.I. Flow Control Accessories is among the world leaders in the development, manufacture and distribution of liquid transmission accessories. A.R.I. engineers have developed a wide range of sophisticated valves made from various types of metals and composite materials. The valves are designed for a variety of applications. Our engineers are working constantly to broaden the range of products, improve and enhance existing product lines and develop new product lines. We incorporate the highest standards of quality control in compliance with Israeli and international standards.
Most of the A.R.I. products are protected by registered patents. A.R.I. operations, development and marketing systems comply with the requirements of the international ISO 9001 and ISO 14000 standards and are certified as such.

The A.R.I. Commitment

A.R.I. is committed to respond to the needs of a changing market. To do so, we strive for a high standard of quality, innovation and advanced technological development as our principal objective.
At A.R.I., we focus on providing products with longevity and minimal maintenance. We offer a comprehensive warranty, excellent service, consulting and training for each customer – at the plant, in the field or at any installation site, as necessary.

Air Valves

The A.R.I. line of automatic air release valves and the automatic air release components of A.R.I. combination air valves are based on the rolling seal technology. The A.R.I. patented sealing mechanism replaces traditional configurations that incorporate a ball float closing against a round orifice. While the system is under pressure the A.R.I. rolling seal mechanism, with its aerodynamically-designed float, releases air in large quantities, often greater than in traditional valves. They also provide for the soft dynamic closure of the valve. This concept of a rolling seal mechanism enabled A.R.I. to develop small, lightweight, cost effective air valves.
The self-cleaning feature of the rolling seal mechanism greatly reduces the possibility of clogging, leaking and the adhesion of suspended particles to the rolling seal surface.
The valve body and interior components are made of corrosion-resistant materials. This ensures years of corrosion-free and maintenance-free operation, even under extreme environmental conditions.
The A.R.I. line of products also includes a wide variety of air & vacuum and combination air valves. They are made of the same quality materials as the automatic air release valves and provide the same level of quality and assurances.
These valves are offered in dimensions of 1/2” to 1” (automatic air release valves) and 1" to 12"(air & vacuum and combination air valves). They provide solutions for various applications in all industrial fields. These products are lightweight, have a compact profile and are offered at competitive prices.

Air in Liquid Transmission System

The quantity of free air must be controlled in liquid transmission systems. The presence of air/gas bubbles and pockets can be beneficial or detrimental to the transmission system under different conditions. The absence of air, such as exist under vacuum conditions, prevents suitable protection for the transmission systems.

Damage caused by the presence of air in the system

1. Air blockage in the line causes unstable flow of the liquid and, in extreme circumstances, a total stoppage of flow.
2. High head losses, resulting in large energy losses.
3 The impact of surge, as a result of the presence of air in the system, can cause damage to pipes, accessories and connectors.
4. Erroneous readings of water meters and automatic metering valves.
5. Extensive damage to impeller systems in water meters, flow regulators, sprinklers and sprayers.
6. Pitting and increased corrosion in metal components of the systems.
7. Safety risks to operators increase due to the possibility of high energy bursts in locations where there are concentrations of compressed air.

Damage caused by the absence of air in the system

Vacuum enhanced problems and damages:

- Suction of mud and dirt through faulty connections, cracks in pipes and accessories, etc.
- Suction of seals and gaskets, in–line fittings, and other internal accessories of pipes.
- Uncontrolled suction of injected chemicals into the system.
- Pipe or accessory collapse.
- In some cases, the absence of an air cushion can increase the damages of surge and slam phenomena.

Using A.R.I Air Valves to Control Air and Prevent Damage

There are three principal types of air valves used in liquid transmission applications:

Air & Vacuum Valves
Automatic Air Release Valves
Combination (double orifice) Air Valves

Air & Vacuum Valves automatically discharge air at high flow rates during filling of the system and admit air at high flow rates during draining, at water column separation, and in cases of down-surge in the system.
Air & vacuum valves are known also as: large orifice air valves, vacuum breakers, low-pressure air valves and air vacuum valves.
Automatic Air Release Valves release air entrapped in the system while under pressure. The air release flow rates of the automatic air release valves are lower than those of the air & vacuum valves. They are also known as: air release valves and small orifice air valves.
Combination Air Valves include both air & vacuum and automatic air release components in one unit. They perform both functions:
- They discharge air at high flow rates during filling of the system and admit air at high flow rates at drainage or water column separation, AND
- They release entrapped air while the system is under pressure.

Combination air valves are also known as double orifice air valves.

Installation and Location

It is highly recommended that a basic review be made before selecting the appropriate air valves and determining their sizes and locations:
- The chemical composition of the liquid that passes through them.
- The possibility of extreme pressure changes such as up-surges and down-surges.
- Analysis using **ARIavCAD** software for efficient design of the system (software available from A.R.I).

Typical installation locations:
- In pump stations.
- At locations where pressure drops.
- At peaks along the line.
- At locations of large convex slope changes
- Along line segments without air valves.
- Near isolating valves on the line.
- On filter setups.
- Before flow meters and automatic devices.
- At line ends.

Recommendations for the Determination of the Required Diameter of Air & Vacuum and Combination Air Valves

To determine the diameter of air valve required, the first essential step is to define the task that the air valve must perform and the level of protection that the valve must provide.

The principle tasks of an air valve are:

1 - The controlled or free discharge of air during the line filling stage:

A. Controlled discharge – The air valve diameter is determined in order to limit flow / filling speed.

B. Free discharge – The air valve is used to discharge air during line filling, but is not used to limit flow / filling speed.

2- Intake of air to prevent negative pressure (vacuum), down-surge and/or cavitation:

A. When the line is drained through drainage valves with a defined location and size.

B. When the line bursts at predefined or not defined points along its length; it's bursting up to a pre-determined size of burst in the pipe and the free drainage of water out of the line through the burst.

C. When there is water column separation consequential to extreme changes in the regimen of water flow through the pipe.

The required air flow rate and the air valve diameter are determined in accordance with the objective sought when installing the air valve and as explained below:

- If the purpose of the air valve is only to limit filling speed – the required air release speed is equal to the filling rate (for the system), which is a function of the required filling rate.

- If the purpose of the air valve is to protect the system in the event of an burst, which splits the pipe across its entire cross section, with consequential free flowing drainage of the line, the accepted method is to determine the required rate of air intake according to a burst analysis based on one of the flow equations, such as the Hazen – Williams equation:

Burst Analysis

The burst analysis is based on the Hazen Williams Equation:

$$Q_B = K C_{HW} D^{2.63} (h_f / L_{act})^{0.54} \quad \text{and} \quad L_{act} = (h_f^2 + L_{hp}^2)^{0.5}$$

Where, in our case:

Q_B = Air intake flow rate requirement for vacuum protection at full diameter pipe burst – ft3/sec

K = Unit constant = 0.432

C_{HW} = Hazen Williams Coefficient for the pipe

D = Diameter of pipe – ft

h_f = Elevation change between the two ends of the pipe segment being analyzed – ft

L_{act} = Actual length of the pipe segment (not its horizontal projection)- ft

L_{hp} = Length of the horizontal projection of the pipe segment - ft

Given that the results of this analysis are often extreme, the common practice is to supply air at a percentage of the calculated results.

A.R.I. does not recommend using the Burst Equation.

- If the purpose of the air valve is to protect the system during drainage through a defined drainage valve or at pipe rupture, it is recommended to use the drainage and rupture analysis based on the orifice equation.

Drainage and Rupture Analyses

Air intake flow rate requirement at drainage through a drain valve or a rupture is:

$$1.\ Q_d = C_d(\pi D_d^{2}/4)(2g\ \Delta h)^{0.5}$$

For drains or ruptures whose equivalent diameters are greater than 30% of the pipe diameter:

$$2.\ Q_d = MC_d(\pi D_d^{2}/4)(2g\ \Delta h)^{0.5} \text{ and } M= \{1/[1-(D_d/D_p)^4]\}0.5$$

Where:

Q_d	= Air intake flow rate requirement – ft3/sec
C_d	= Orifice coefficient – 0.6 is a common default value
D_d	= Drain valve or rupture equivalent diameter - ft
g	= Gravitational acceleration –32.174 ft/sec2
Δh	= Elevation difference between the air valve and the drain valve or rupture - ft
M	= Correction factor
D_p	= Diameter of the pipe - ft

Here, the initial Q_d was calculated with no losses. After the initial calculation of Q_d , we calculate the Hazen Williams friction head loss, hf due to this initial Q_d:

$$3.\ h_f = Q_d^{1.852}L_{act}\ /(K^{1.852}C_d^{1.852}D_d^{4.87}) \text{ and}$$
$$L_{act} = (\Delta h_1^{2}+L_{hp1}^{2})^{0.5}+ (\Delta h_2^{2}+L_{hp2}^{2})^{0.5}+\ldots (\Delta h_n^{2}+L_{hpn}^{2})^{0.5}$$

Where:

h_f	= Hazen Williams friction head loss due to the initial Qd - ft
K	= unit constant = 0.432
L_{act}	= Actual total pipe length between the air valve and the drain or rupture – ft
$\Delta h_1, \Delta h_2, \ldots \Delta h_n$	= Elevation change of each of the pipe segments between the air valve and the drain or rupture - ft
$L_{hp1}, L_{hp2}, \ldots L_{hpn}$	= Length of the horizontal projection of each of the pipe segments between the air valve and the drain or rupture - ft

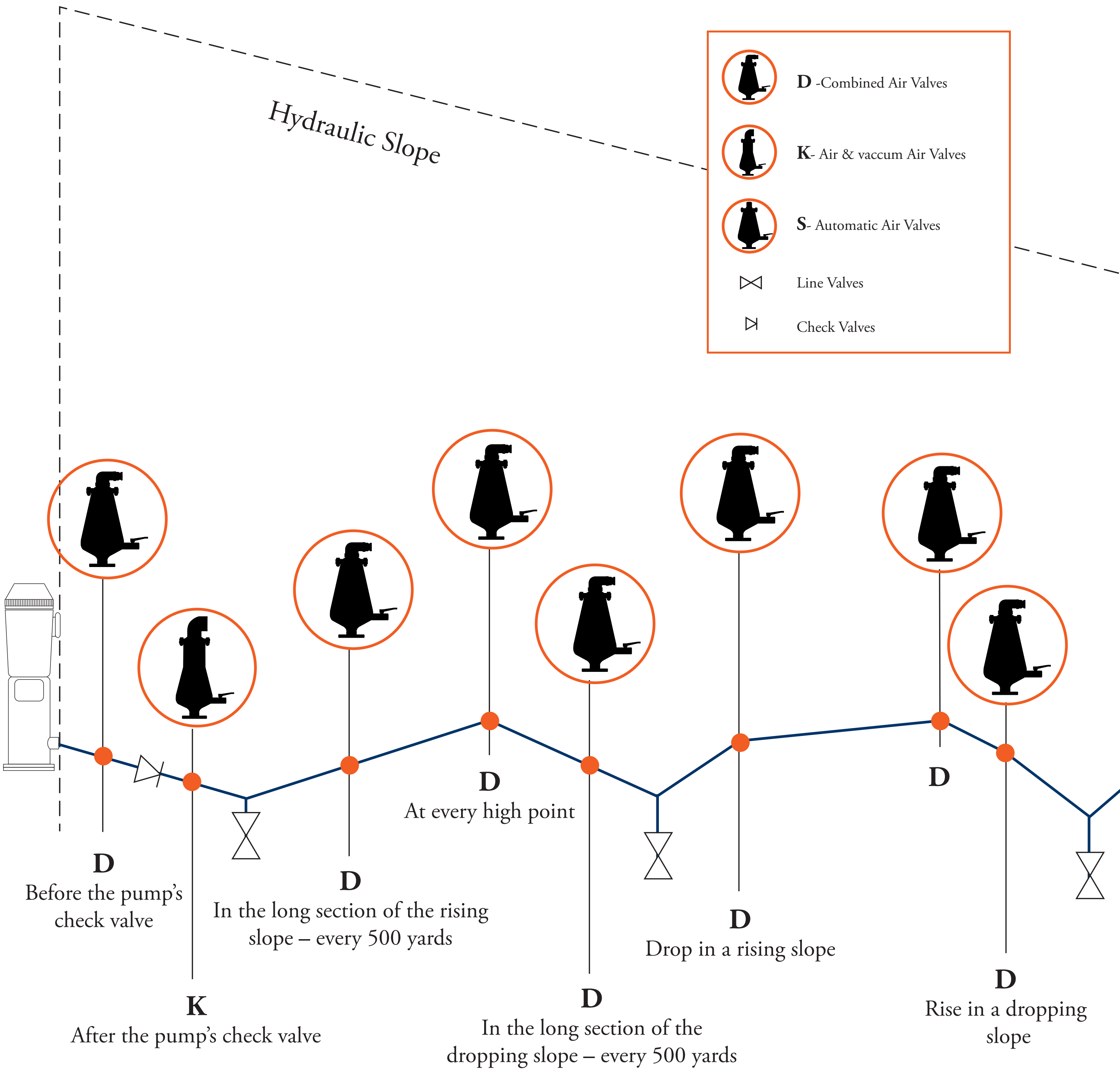
Now, we calculate the new Δh by subtracting hf from the initial Δh:

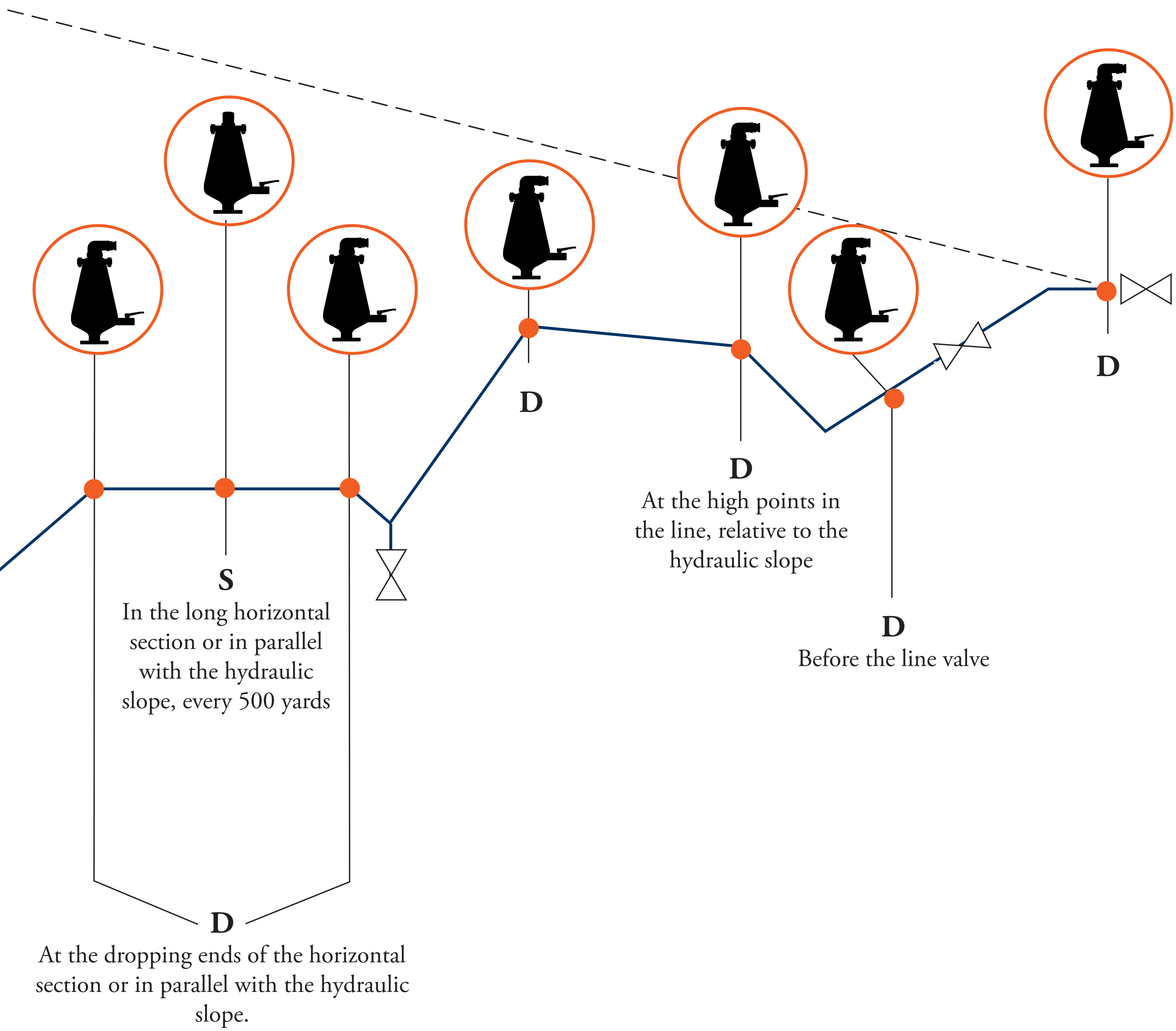
$$4.\ \text{New } \Delta h = \Delta h - hf$$

Use this New Δh in either equation 1 or equation 2 above (depending on the size of the drain valve or rupture, relative to the pipe diameter), and calculate the final Q_d.

Given that the air valve diameter required must be calculated separately for each separate air point in the system, the scope of the calculation work required is very considerable.
To solve this problem, A.R.I. has developed a unique program – **ARIavCAD**. The **ARIavCAD** program determines the diameter and the location for each air valve and selects from the range of valves manufactured by A.R.I., the most appropriate air valve for installation at each point. Use of the **ARIavCAD** program is highly recommended. For further details, please contact the A.R.I. Service Department.

Location of Air Valves, Relative to the Line of Fluids





D
D
D
At the high points in the line, relative to the hydraulic slope
D
Before the line valve
S
In the long horizontal section or in parallel with the hydraulic slope, every 500 yards
D
At the dropping ends of the horizontal section or in parallel with the hydraulic slope.