HOW TO CHOOSE THE RIGHT SIZE **AIR RELEASE VALVE**

TECHNICAL ARTICLE

FLOMATIC VALVES

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INTRODUCTION

One size-fits-all is not a good way of thinking when it comes to selecting air and vacuum valves and air release valves. In fact, choosing the wrong size valve can negate the purpose of an air valve completely.

Air valves are hydro-mechanical valves designed to automatically release or admit air during the filling or draining of a piping system. Air comes out of solution in a pipeline because of low-pressure zones created by partially open valves, variations in flow velocity and changes in pipeline system elevation. An air pocket collected in a system high points will reduce the flow of water in a pipeline by reducing the flow area and in severe cases, completely air bind the pipeline and stop the flow of water. Air pockets in pipelines are difficult to detect and will reduce the pipeline system's overall efficiency due to additional head loss and increased power consumption required to pump the water.

Proper sizing of air and vacuum valves is an important factor to consider when installing a new system or repairing an older one. **Doing a little background research on your operation and following a few simple equations will alleviate future headaches and potential catastrophe from wrong size or type air/vacuum valves.**

There are three main types of air and vacuum valves — ***air/vacuum valves, air release valves*** and ***combination air valves*** — and each one has its own unique requirement to consider when sizing.

> **The American Water Works Association (AWWA) cover these in much more detail in their AWWA M51 Manual and Standard C512-15: "Air-Release, Air/Vacuum, and Combination Air Valves for Water and Wastewater Service."**

AIR/VACUUM VALVE

Air/vacuum valves, also known as large orifice valves, are automatic float operated valves with two overall functions. The float operated valve controls the exhaust of the air during the filling of a pipe system and will simply close when all air is exhausted. The valve will also fully open during draining or if a negative pressure occurs. When sizing this valve, consider both the filling and draining of the piping system separately, as explained in more detail below.

An important valve sizing consideration is that **this type of valve will not release accumulated air from a piping system while the system is in operation and under pressure.** The air/vacuum valve is typically equipped with a simple double guided, float-operated valve seat that is normally open during vacuum piping condition and fully closed during pressurized system operating conditions.

The first sizing step is to determine your maximum flow rate in gallons per minute (gpm) in the pipeline. This may be a known constant for your specific system, or if gravity-based, you may need to calculate it using the diameter and slope of the pipeline. **Once that is understood it can be used to determine the rate at which air will exhaust in cubic feet per minute (cfm) when filling the piping system**. Using the flow rate in gallons per minute, divide that value by 7.48 gallons per cubic foot to give you your cfm of exhausted air.

The example below uses a 12-inch pipeline with a designed flow rate of 3,000 gpm, which is about 8.5 feet per second flow velocity and equates to 401 cfm of air. **Use the calculated cfm of air discharge and at a pressure differential no greater than 2 psi to determine the appropriate valve size represented in the chart below.**

Using the table, 401 cfm falls between 387 and 445, in the 2-inch orifice size column, indicating a 2-inch valve is necessary for proper air volume exhaust.

$$\text{CFM} = \frac{\text{3,000 GPM}}{\text{7.48 gallons/cubic feet}} = \text{401 CFM}$$

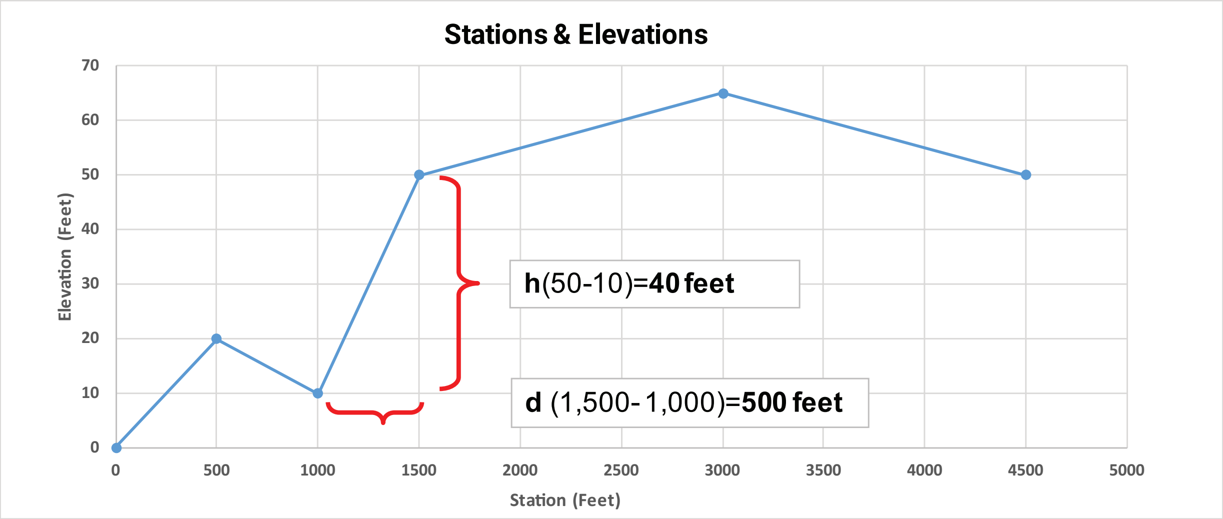
Air Discharge Valve Orifice Size (Inch)												
Diff. Pressure (psig)	**1**	**2**	**3**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
1	79	317	712	1,270	2,850	5,070	7,910	11,400	15,500	20,200	25,600	31,700
1.5	97	387	870	1,550	3,480	6,190	9,670	14,000	18,900	24,700	31,300	38,600
2	111	445	1,000	1,780	4,010	7,120	11,100	16,000	21,800	28,500	36,100	44,500
2.5	124	497	1,120	1,990	4,470	7,950	12,400	17,900	24,300	31,800	40,200	49,600
3	136	543	1,220	2,170	4,890	8,690	13,600	19,500	26,600	34,700	44,000	54,300
3.5	146	585	1,320	2,340	[illegible]	[illegible]	[illegible]	[illegible]	28,700	37,500	47,400	58,500
4	156	625	1,410	2,500	[illegible]	[illegible]	[illegible]	[illegible]	30,600	40,000	50,600	62,500
4.5	165	662	1,490	2,650	5,960	10,600	16,500	23,800	32,400	42,300	53,600	66,200
5	174	697	1,570	2,790	6,270	11,100	17,400	25,100	34,100	44,600	56,400	69,700

NOT RECOMMENDED AREA

Metric conversions in. x 25.4 = mm, cfm x 0.4719 = L/sec, psi x 6.89476 = kPa.

When using an air/vacuum valve to admit air into the pipeline to drain for repair or maintenance, it may be necessary to use a different size than the valve previously selected for filling the piping system.

When calculating and sizing this vacuum valve function, take into consideration the pipeline slope (S) and a percentage of the vertical height (h) of the slope in relationship to horizontal distance (d) to determine the gravity flow. When calculating the percent of vertical slope or grade, use the steepest grade. In this example, the steepest grade is between stations 1,000 and 1,500. Between these stations with a horizontal distance of 500 feet there is a vertical height difference of 40 feet or 8%.



$$S \text{ (slope)} = \frac{h \text{ (height)}}{d \text{ (distance)}} \quad \frac{40 \text{ feet}}{500 \text{ feet}} = 8\%$$

Based on this piping slope information, use a different equation to calculate the air volume (Q) in cfm needed to have the water properly drain back under these gravity and vacuum conditions. Use a Chezy flow coefficient (C), which in this case is 110. That value indicates the roughness of the pipe. For concrete it would be 120, steel is 130 and PVC pipe is 190. For this example, with a Chezy flow coefficient of 110, the calculated slope (S) of 8% or 0.08 and the pipe inside diameter (D) of 12 inches; the calculation results is 730 cfm as shown in our example below.

$$Q = \frac{C}{21.27}\sqrt{SD^5} \qquad Q = \frac{110}{21.27}\sqrt{(0.08)(12)^5} = 730 \text{ CFM}$$

The air valve orifice size is typically based on a maximum pressure differential of 5 psi. Since the piping inlet pressure is atmospheric pressure (14.7 psi), then any negative low pipeline pressure may produce sonic flow. Sonic flow will occur when the outlet-to-inlet pressure ratio falls too low which may damage the system and potentially collapse larger diameter piping.

The valve needed to allow an air-inflow at a 730 cfm (between 688 CFM and 824 CFM as indicated in the chart below), within the 5 psi pressure differential is a 3-inch size according to the "Air-Inflow Valve Orifice Diameter". (Table on the next page)

After determining valve size using both methods, select the larger of the two air valves calculated. In our example the 3-inch valve orifice size, rather than the smaller 2-inch size valve calculated above is needed to exhaust 401 cfm of air from the pipeline.

Air-Inflow Valve Orifice Diameter (Inch)												
Diff. Pressure (PSIG)	1	2	3	4	6	8	10	12	14	16	18	20
1.0	76	306	688	1,220	2,750	4,890	7,650	11,000	15,000	19,600	24,800	30,600
1.5	92	366	824	1,470	3,300	5,860	9,160	13,200	17,900	23,500	29,700	36,700
2.0	103	414	931	1,660	3,720	6,620	10,300	14,900	20,300	26,500	33,500	41,400
2.5	113	452	1,020	1,810	4,070	7,230	11,300	16,300	22,100	28,900	36,600	45,200
3.0	121	484	1090	1,930	4,350	7,740	12,100	17,400	23,700	31,000	39,200	48,300
3.5	127	510	1,150	2,040	4,590	8,160	12,700	18,400	25,000	32,600	41,300	51,000
4.0	133	532	1200	2,130	4,780	8,510	13,300	19,100	26,100	34,000	43,000	53,200
4.5	137	550	1,240	2,200	4,950	8,800	13,700	19,800	26,900	35,200	44,500	55,000
5.0	141	565	1270	2,260	5,080	9,030	14,100	20,300	27,700	36,100	45,700	56,500

Metric conversions- in. x 25.4 = mm, cfm x 0.4719 = L/sec, psi **x** 6.89476 = kPa.

It is also important to note that when filling and draining a piping system, it should be done at a control flow velocity of about 1 to 2 feet per second to minimize pressure transients. In addition, if there is a risk of larger pipes collapsing from vacuum formation, you will need to determine the maximum tolerable pressure differential using the formula below, which includes a safety factor of 4.

P = 16,250,000 x (T/D)3

P = Pipe Collapse pressure (psi), T = Pipe wall thickness (in.), D = Pipe diameter (in.)

After calculating P, if it is lower than 5 psi, use the cfm value determined with the above equation. If P is greater than 5 psi, pipe collapse may be a concern on large-diameter pipe. It is recommended that a different type pipe or wall thickness is used, and the pipe manufacturer be consulted to provide maximum external collapse pressures.

The above pipe collapse formula is applicable to a pipe submerged or an aboveground environment. Pipes used in buried service with firm soil compaction are not as prone to vacuum collapse.

Pipe Size: 12"				Pipe Size: 24"			
p	Collapse Pressure =	**2,880.1**	psi	**p**	Collapse Pressure =	**9.5**	psi
t	Pipe Thickness =	0.406	Inch	**t**	Pipe Thickness =	0.125	Inch
d	Mean Pipe Dimater =	11.532	Inch	**d**	Mean Pipe Dimater =	23.875	Inch
ΔP	Collapse Pressure =	5	PSI	**ΔP**	Collapse Pressure =	5	PSI
SF	Safety Factor =	4	Dimensionless	**SF**	Safety Factor =	4	Dimensionless
P_C	Collapse Pressure =	**720.03**	**psi**	**P_C**	Collapse Pressure =	**2.37**	**psi**
	Difference P_C - ΔP =	**715.03**	**psi**		**Difference P_C - ΔP =**	**(2.63)**	**psi**

In the example above, with a 12-inch pipe, there is no concern with the collapsing pressure calculated over 715 psi. However, if a 24-inch pipe was used with a wall thickness of only 1/8 inch, the collapsing pressure would only be 2.3 psi. This could be a serious problem when 5 psi is the minimum pressure differential needed to protect the pipe under vacuum conditions.

AIR RELEASE VALVES

The air release valve is the workhorse of air and vacuum valves automatically letting air out from the system high points all the time while under pressure during system operation. **Clean water can typically contain 2% air, while wastewater contains about 6%. Air is compressible in the piping system while water is not, and as a result of the changes in pressures in the system, it will come out of solution**. The air will accumulate in the high point of the piping system, causing higher flow restriction, which leads to higher operational costs. Also, if air is not properly vented out from the piping system, you may have water hammer, and higher piping corrosion and maintenance costs.

Air release valves are also referred to as small orifice valves due to their smaller orifice size in comparison to air/vacuum valves. They are typically connected to a compounded hinged float mechanism versus a simple float seat operation in the air/vacuum valves. This is how air release valves get their hydro mechanical advantage to open/close and vent air under pressurized system operation.

Sizing an air pressure relief valve can be a challenging task without a little background knowledge and experience. The above example of a 12-inch pipe with a flow rate of 3,000 gpm, falls in the table between the range of 2,001-5,000 gpm, indicating a 2% air release factor. Use that and the formula below to calculate air discharge rate in cfm.

EXAMPLE:

Flow Range in (GPM)		Conversion Factor		Air Release Factor		Air Discharge Rate (cu. ft.)
0-1,000	÷	7.48 gal/cu.ft	x	6%	=	CFM
1,001-2,000	÷	7.48 gal/cu.ft	x	5%	=	CFM
2,001-5,000	÷	7.48 gal/cu.ft	x	2%	=	CFM
5,001-50,000	÷	7.48 gal/cu.ft	x	1.50%	=	CFM
50,001-higher	÷	7.48 gal/cu.ft	x	1.20%	=	CFM
Flow (GPM)	÷	**7.48**	x	**% Air Release Factor**	=	**Air Discharge Rate (CFM)**
3,000 (GPM)	÷	**7.48**	x	**2 % Air Release Factor**	=	**8.0 (CFM)**

Based on this calculation, we need to discharge 8.0 cfm of air in the 12-inch pipeline at 3,000 gpm.

Use the table labeled Air Discharge Capacity (next page) that shows orifice size based on working pressure to determine that a valve size with a 3/32-inch orifice diameter is needed if working pressure is 100 psi. In our example, the 3/32-inch orifice has a 9.5 cfm capacity (see highlighted in table), well within the requirements.

The air volume vented through the orifice of the air-release valve at the pipeline is directly related to the working pressure at that valve location. As you can see from the Air Discharge Capacity table, the higher the pressure the more air volume capacity or cfm flow.

It’s not over yet. A 3/32-inch hole on the side of a 12-inch pipe would not do much in relieving air. A valve body that has an internal body is needed so that it can accumulate enough air to activate the cam and lever float mechanism to open/close the valve. Here comes the part you cannot calculate: selecting the air release valve body size and connection.

Air Discharge Capacity in Cubic Feet per Minute

Orifice Size (Inches)	Working Pressure PSI				
	50	100	150	200	250
1/32	0.6	1.1	1.5	2.0	2.5
3/64	1.3	2.4	3.4	4.5	5.5
1/16	2.4	4.2	6.1	8.1	9.9
5/64	3.7	6.6	9.6	12.4	15.3
3/32	5.3	9.5	13.8	17.9	22.1
7/64	7.3	12.9	18.6	24.4	30.0
1/8	9.6	16.9	24.4	31.9	39.2
9/64	12.1	21.3	30.8	40.3	49.5
5/32	14.9	26.3	37.9	49.5	61.1
3/16	21.4	37.7	54.6	72.0	88.0
1/4	38.1	68	98	127.0	157.0
5/16	59.0	105.0	152.0	198.0	244.0
1/6	86	152	220	287.0	352.0
7/16	117	205	298	390.0	480.0
1/2	153	270	390	510.0	627.0

Orifice Size for Various Pressure Ranges

Valve Size (Inches)	Operating Pressure in LBS.					
	0 to 50	0 to 100	0 to 150	0 to 200	0 to 250	0 to 300
3/8", 1/2", 3/4"	1/8"	1/16"	1/16"	3/64"	1/32"	1/32"
1"	5/16"	5/16"	1/4"	3/16"	5/32"	1/8"
2"	3/8"	3/8"	5/16"	1/4"	3/16"	5/32"
2 1/2"	5/8"	1/2"	7/16"	3/8"	5/16"	1/4"
3"	3/4"	5/8"	1/2"	7/16"	5/16"	1/4"
4"	1"	3/4"	5/8"	1/2"	7/16"	3/8"

The Air Release Valve inlet connection pipe size shall be as large as possible to maximize the exchange of air and water in the valve body. Based on industry practice, a 5/16 inch orifice at 100 psi operating pressure a 1-inch size valve should work fine in on our above example (see circle in above chart).

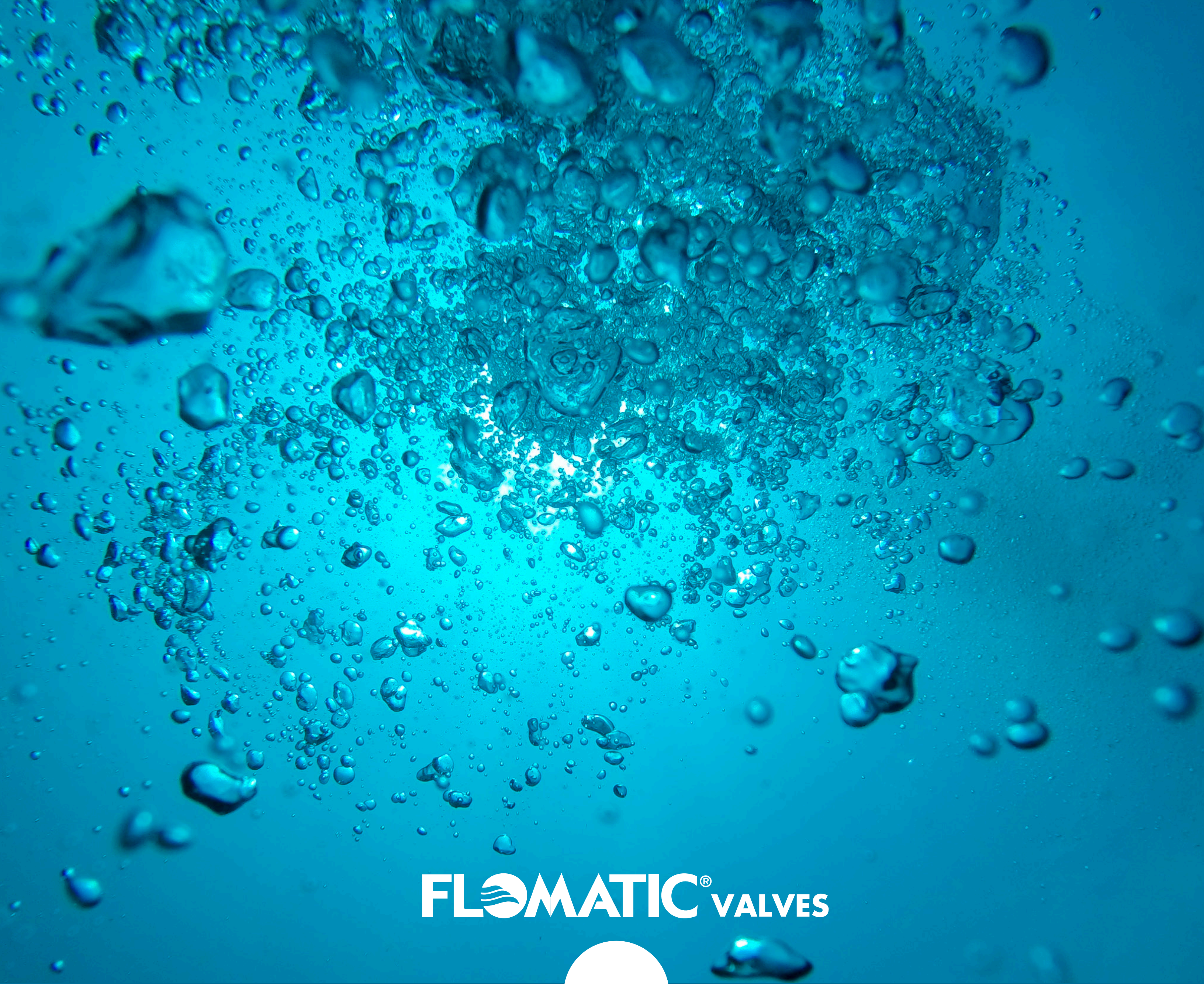
COMBINATION AIR/VACUUM VALVES

Combination air/vacuum valves are simply an economical and practical combination of the air/vacuum valves and the air release valve in one body configuration. Typically, these air combination valves are available in smaller sizes, from 1/2 to 3 inch. In larger sizes, the larger air/vacuum valve may have the smaller air release valve attached on the side of the larger air/vacuum valve body. The sizing of these combination valves follows generally the same steps as explained above.

The air valve, regardless of type, should be installed as close to the pipe as possible with an isolation valve. Isolation valves need to be full-ported and connected to the top of the pipeline to facilitate maintenance.

A good preventive maintenance schedule is also very important for all air and vacuum valves, as they are often located throughout the piping system in hard-to-access places. This is often overlooked and misunderstood until after the valves fail in service. You will find that when your air and vacuum valves are properly sized and maintained they will make your piping system more efficient with less maintenance.

When it comes time to install or replace air pressure relief valves and air and vacuum valves, make sure you consider these factors, and when in doubt, contact a valve professional. Experience and familiarity go a long way in obtaining the proper size valve for your specific application.



As a diversified U.S. valve manufacturer producing valve products in sizes ranging from ¼" through 36", in various types for the Municipal, Industrial, Domestic and Irrigation Markets, please consider Flomatic air/vacuum valves, air release valves and combination air valves for your next project.

For additional questions on the proper sizing and selection of your Air Release and Air Vacuum Valves please contact Flomatic at 518-761-9797 or visit us on-line at wwww.flomatic.com.