

Maxtek Inc

Model MV-112

Piezoelectric Gas Leak Valve

Specifications

VALVE TYPE	PIEZOELECTRIC CRYSTAL
CONTROLLABLE GASSES	ANY COMPATIBLE WITH MATERIALS
FLOW RANGE	0-500 SCCM
CLOSED LEAK RATE	$< 5 \times 10^{-8}$ SCC/SEC (1 ATM HE ON INLET)
RESPONSE TIME	2 MILLISEC
MAXIMUM INLET PRESSURE	50 PSI
DRIVE REQUIREMENT	0-100 VDC @ 10 μ A or 0-24 VDC @ 15mA
OPERATING TEMPERATURE RANGE	+10°C TO +60°C
MATERIALS	STAINLESS STEEL, VITON, TEFLON, NICKEL PLATED CRYSTAL
INLET & OUTLET CONNECTIONS	7/16-20 O-RING PORTS PER SAE J514 1/4" SWAGELOK™ *FITTINGS ARE
STANDARD	1/4" VCR CAJON™ **FITTINGS OPTIONAL
ELECTRICAL CONNECTOR	STANDARD BNC
WEIGHT	800 GRAMS

* SWAGELOK IS A REGISTERED TRADEMARK OF THE SWAGELOK CO.

** CAJON IS A REGISTERED TRADEMARK OF THE CAJON CO.

Maxtek, Inc

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DESCRIPTION	MAXTEK PART NO.	REQ'D
HOUSING	112409-1	1
COVER, HOUSING	112408	1
VALVE SEAT	112401	1
RETAINER, CRYSTAL	112402	1
NUT, SEAT ADJUSTMENT	112403	1
SPRING, PRELOAD XTAL	112404	1
BALL, PRELOAD	803111	1
CRYSTAL & SEAL ASSEM	112202	1
FITTING, INLET (1/4" SWAGELOK™)	112411	1
FITTING, INLET (OPTIONAL 1/4" VCR CAJON™)***	112421	1
FITTING, OUTLET (1/4" SWAGELOK™)	803112	1
FITTING, OUTLET (OPTIONAL 1/4" VCR CAJON™)***	803197	1
CONNECTOR (BNC)	888007	1
FILTER ELEMENT	803097	1
SPRING, FILTER	803099	1
SPRING, VALVE SEAT	803100	1
O-RING - VALVE SEAT	803102	2
O-RING - CRYSTAL	803101	1
O-RING - COVER	803103	1
O-RING - FILTER	803107	1
O-RING - INLET & OUTLET	803105	2
O-RING - BNC CONN	803161	1
SCREW, CROSS REC. FILL HD 6-32 × 1/4	800070	8
SCREW, CROSS REC. FILL HD 4-40 × 7/8	800071	2
SCREW, CROSS REX. FILL HD 4-40 × 3/16	800072	3
SCREW, CROSS REC. PAN HD #2-56 × 1/8	800073	1
SCREW, CROSS REC. ROUND HD #0-80 × 1/4	800074	1
WASHER, SPLIT LOCK - #2	800122	1
WASHER, SPLIT LOCK - #4	800128	5
WASHER, SPLIT LOCK - #6	800129	8

***USED ON MV-112 VALVE WITH VCR FITTINGS

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WARRANTY

Maxtek, Inc. guarantees the MV-112 Valve to be free of functional defects in material and workmanship and will perform in accordance to the specifications published by Maxtek, Inc. in the appropriate brochure for a period of one (1) year from the date of original shipment to purchaser. The foregoing warranty is subject to the condition that the valve be properly installed and operated in accordance with instructions provided by Maxtek, Inc. and has not been altered by anyone other than Maxtek, Inc. or has not been subject to abuse, misuse, accident or damage during shipment.

Purchaser's sole and exclusive remedy under the above warranty is limited to, at Maxtek's option, repair or replacement of defective equipment or return to purchaser of the original purchase price. Transportation charges must be prepaid and upon examination by Maxtek the equipment must be found not to comply with the above warranty. In the event that Maxtek elects to refund the purchase price, the equipment shall be the property of Maxtek.

This warranty is in lieu of all other warranties, expressed or implied and constitutes fulfillment of all of Maxtek's liabilities to the purchaser. Maxtek does not warrant that the product can be used for any particular purpose other than that covered by the applicable specifications. Maxtek assumes no liability in any event, for consequential damages for anticipated or lost profits, incidental damage or loss of time or other losses incurred by the purchaser or third party in connection with products covered by this warranty or otherwise.

Repair and service beyond the warranty period will be provided by Maxtek, Inc. on a time and material basis at current Maxtek, Inc. prices.

INSTALLATION AND MAINTENANCE

FEATURES

A piezoelectric valve has several features that are advantageous over other valves. They include no mechanical linkage, no servomotor drives, no wear, no overshooting, fail-safe on loss of power with automatic close, no leakage, external adjustment, minimum flow control and fast response (less than two milliseconds).

For Example: Mass Flow Controller/Valves have a response time of 1 to 10 seconds which is 500 to 5,000 times as long as the MV-112 and Mass Flow Controllers/Valves have a 6 minimum flow rate of about 1,000,000 times higher than the MV-112 minimum rate.

INSTALLATION

Installation of the MV-112 valve consists of plumbing the outlet port of the valve to a suitable port in the vacuum system. The outlet port has a standard Swagelok™ 1/4" tube fitting for this purpose. The gas supply (Note: Inlet pressure must be regulated to 50-PSI max) is connected to the inlet fitting which is also a Swagelok™ 1/4" tube fitting which has been modified to retain the 7-micron inlet filter. Gas flow direction is shown on the I.D. label on the valve housing.

OPERATION

The electrical input to the valve is via a standard BNC female connector. The control voltage is 0-100 VDC. Polarity must be positive to center contact and negative to the housing. Any 0-100 volt DC power supply can be used for manual operation or an automatic pressure controller such as Veeco's APC-100 can be used for closed loop operation.

ADJUSTMENTS

Normally no adjustments are necessary. The valve is adjusted at the factory for a threshold voltage (voltage at which valve starts to open) of 20-30 volts. If this has decreased to the point where the valve is not leak tight, it may be adjusted by removing warning label and turning the adjustment screw. NOTE: The adjustment screw is very sensitive! Care must be used not to damage the crystal or valve seat. NEVER turn adjusting screw more than 1/2 turn total. Evidence of damage caused by improper adjustment or disassembly voids, the warranty. Turn screw in very small increments, (1) degree or less at a time. Turning the screw clockwise increases the threshold voltage. Applying voltage to the valve until a pressure change is noted in the vacuum system or leak detector makes adjustment. Note the voltage at which this occurs and turn screw clockwise to increase voltage required to open valve and counter clockwise to decrease voltage required.

MAINTENANCE

Normally no maintenance is required. If the filter becomes contaminated it is replaceable by removing the inlet fitting (see valve construction drawing). If further maintenance is required return the valve to the factory.

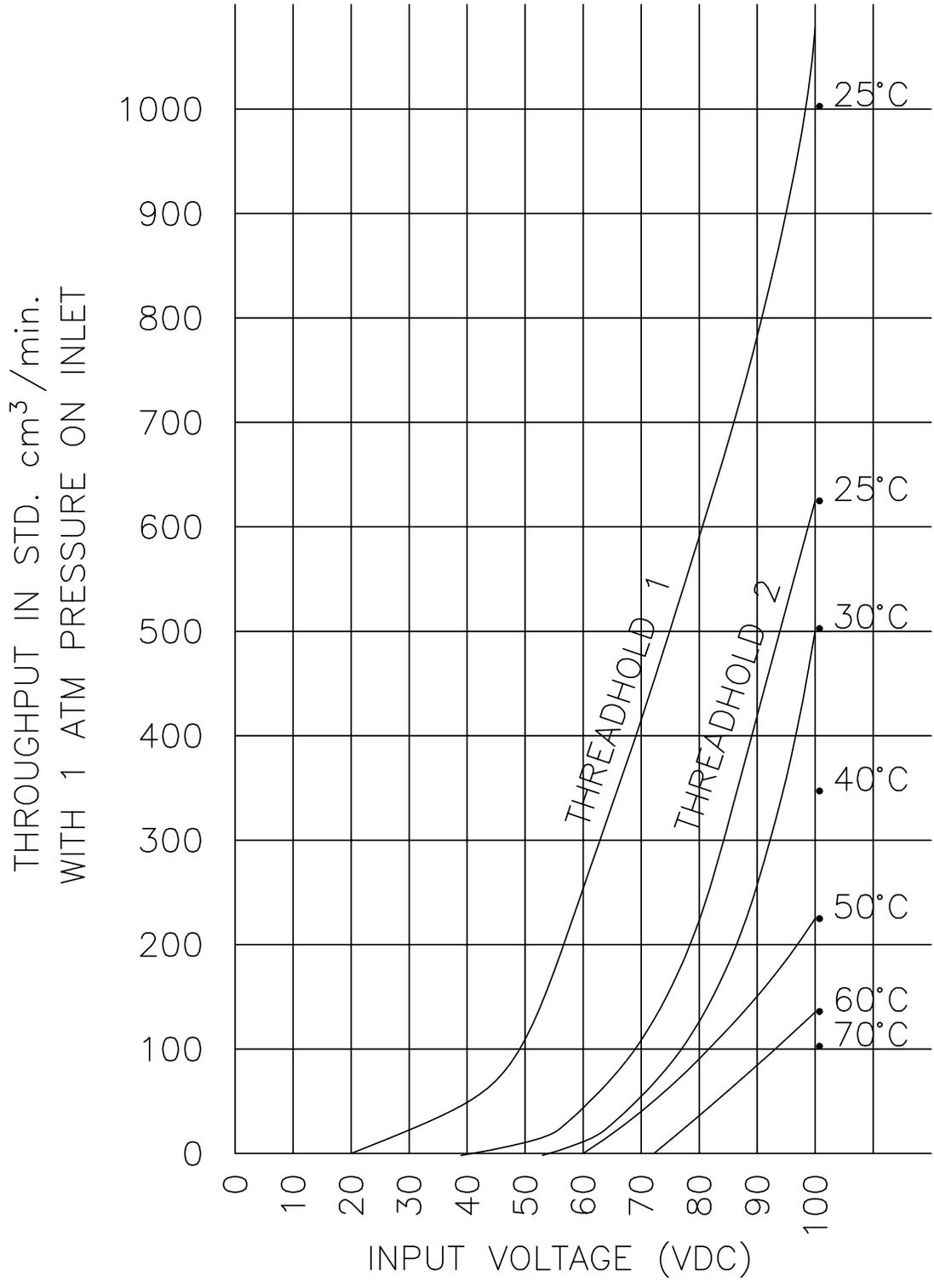


Figure 1 Temperature Effects on Throughput

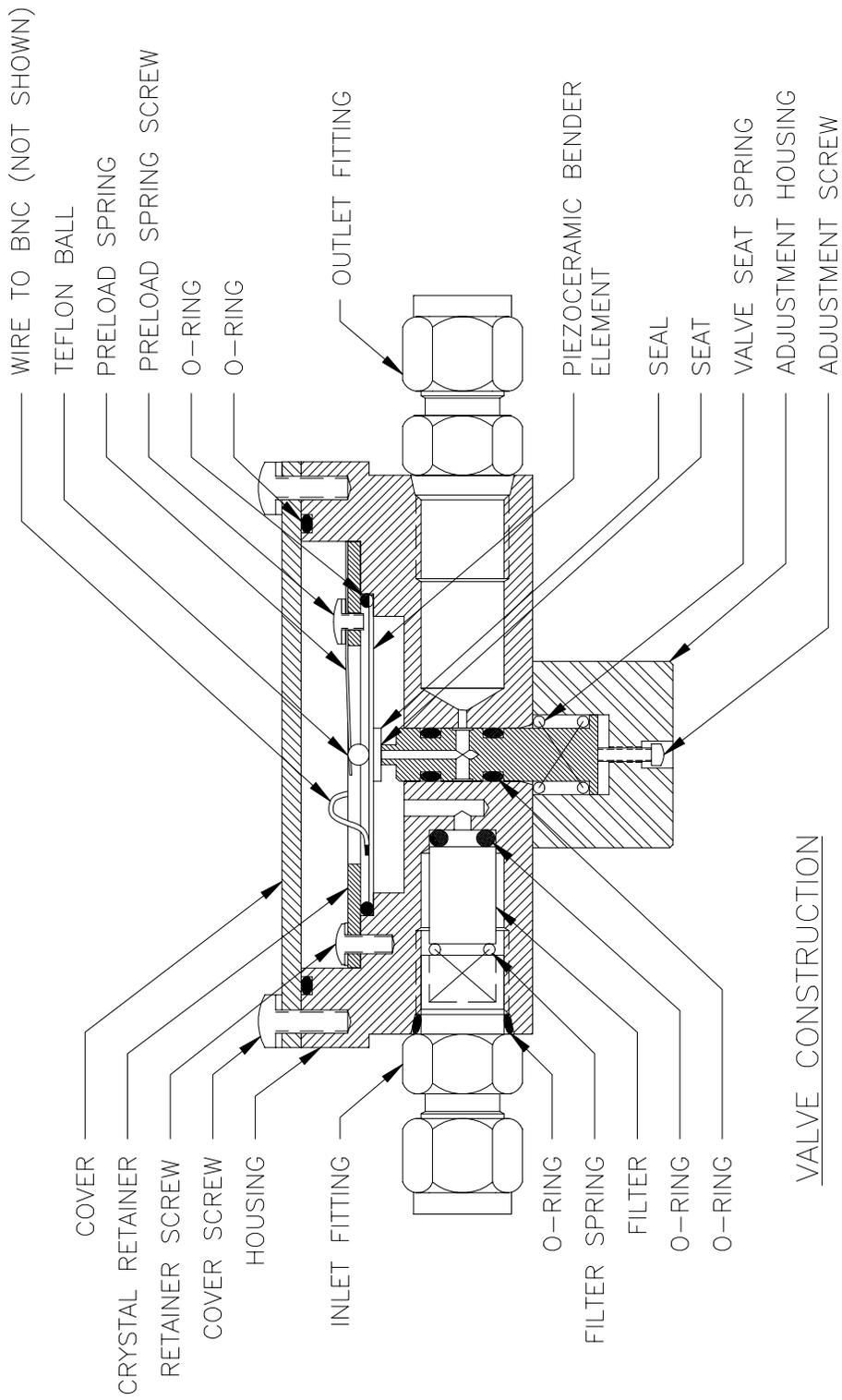


Figure 2 Valve Construction

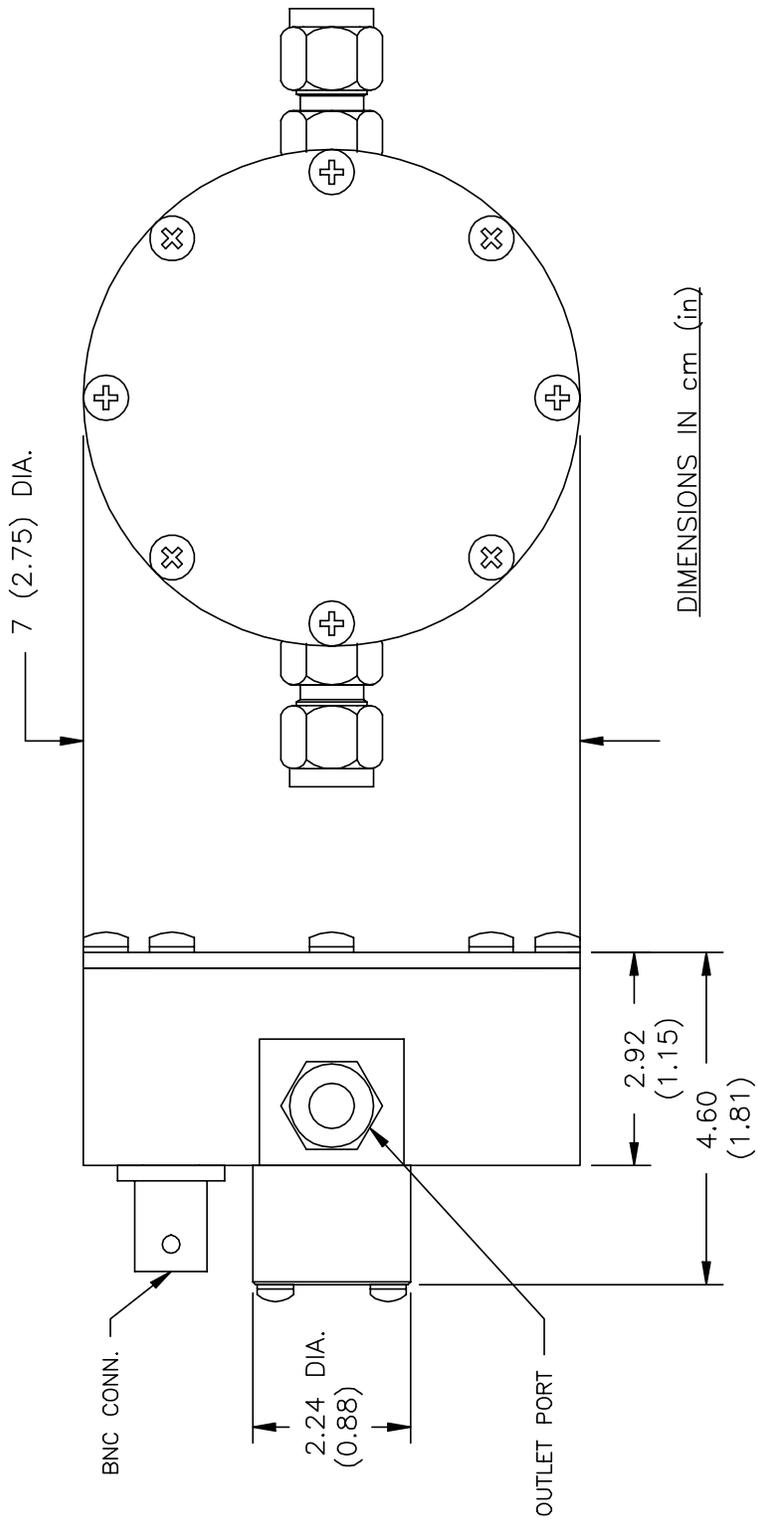


Figure 3 Dimensions in: cm (in)

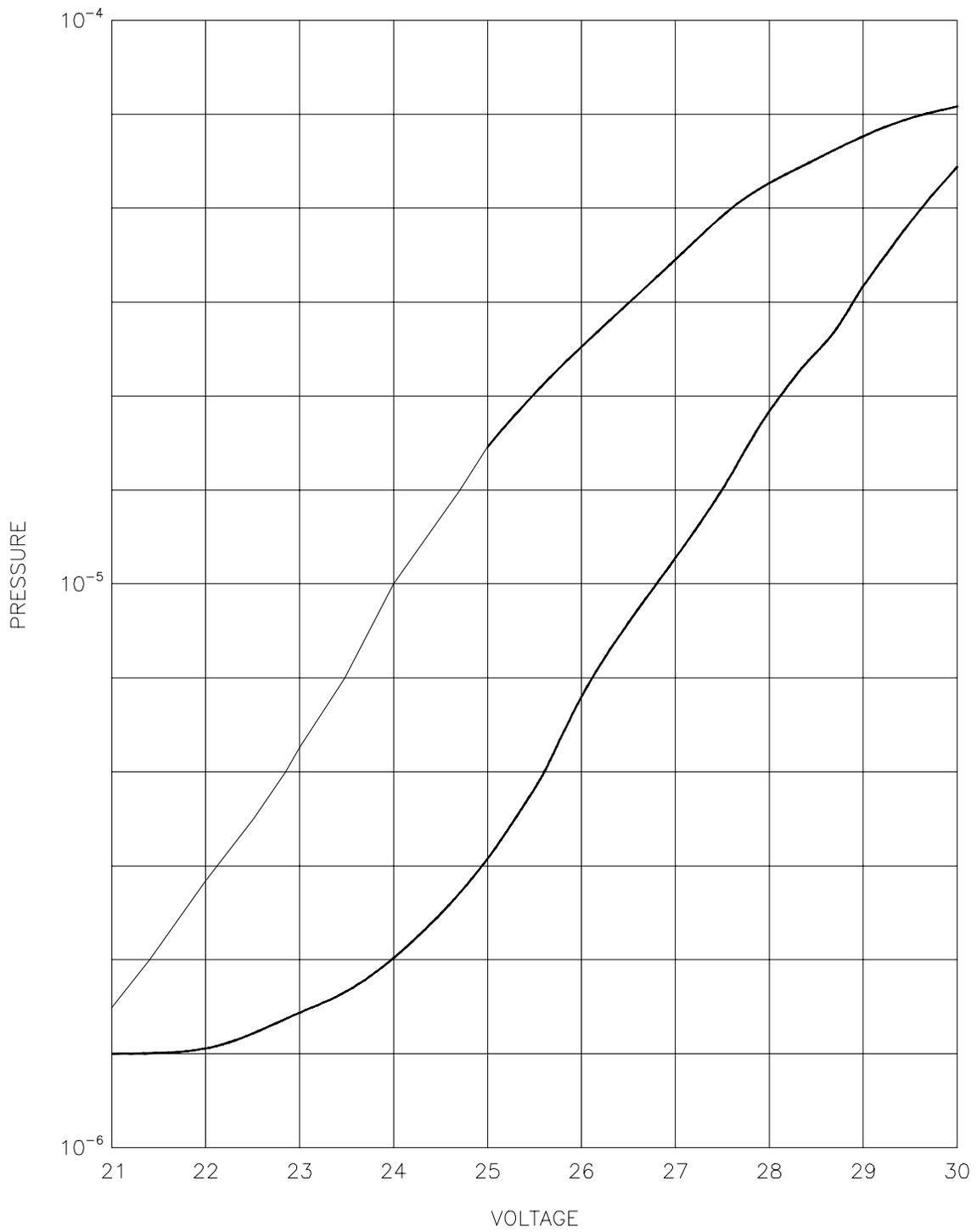
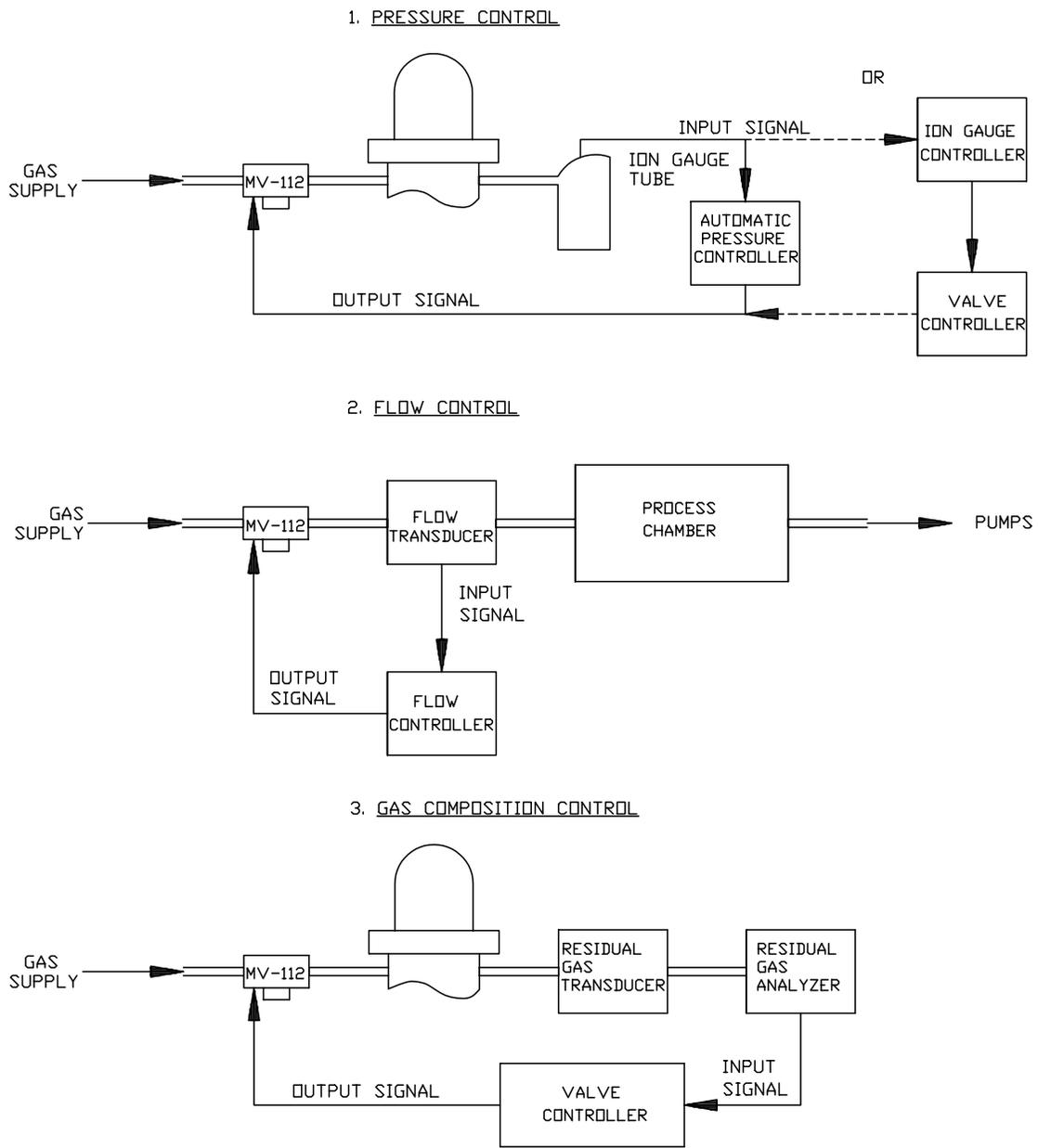


Figure 4 Power versus Pressure



GENERALIZED CLOSED LOOP SYSTEMS

Figure 5 Generalized Closed Loop Systems

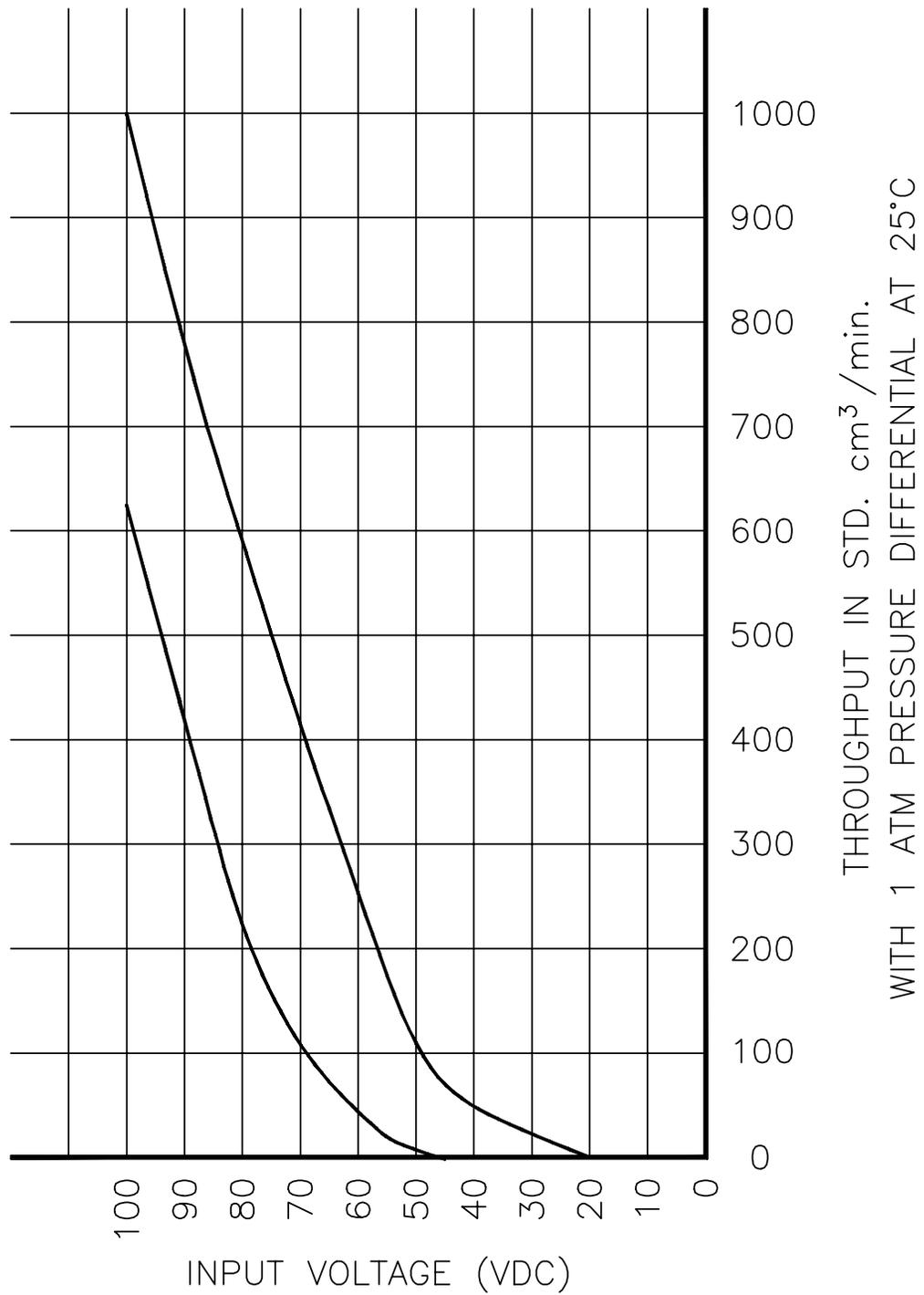


Figure 6 Input Voltage vs. Throughput

APPLICATION OF THE PIEZOELECTRIC VALVE MV-112

The MV-112 Piezoelectric Valve is suitable for applications requiring precision control of gas flow. The following paragraphs outline the use of the valve in these applications including information relative to installation and calibration.

OPERATION-GENERAL

The valve is tested and calibrated at the factory over an input voltage range of 0-100 VDC. This range should not be exceeded in order to maintain factory checked parameters. The signal must be applied to the center of the standard BNC male connector while the ground is connected to the outer body. Any 0-100 VDC power supply can be used for manual operation or an automatic pressure controller can be used for closed loop operation. Compatible controllers are:

CONTROLLER	VENDOR
APC-1000	VEECO
80-1	TYLAN GENERAL
DGC III	PERKIN-ELMER
QUADREX PPC	INFICON
250 B SERIES	MKS

OPEN LOOP OPERATION (MANUAL)

For successful open loop control, the parameter being controlled has to be visibly displayed so that the control voltage (0-100 VDC) to the valve can be manually adjusted and the effects observed. In addition, the system must be slow responding to manually compensate for changes in related parameter.

CLOSED LOOP OPERATION

The most common control system is of the closed loop type and is shown in general terms in Figure 5. The sensor used in the system and fed back to the valve determines the type of system i.e. a pressure sensor typifies a pressure control loop. Between the sensor and the valve, a controller is needed to compare the sensor input with a setpoint and generate an error signal. The error signal is inverted and amplified to increase the voltage to the valve when the sensor is less than the setpoint and decrease the voltage to the valve when the sensor is more than the setpoint. The setpoint is usually a controller adjustment.

The closed loop dynamic response is usually adjusted at the controller. The valve response time of 2 milliseconds or less is much faster than the typical system response making system functionally insensitive to the valve response. This should be compared to the 6 to 10 seconds associated with mass flow valves when picking your system configuration to assure a stable and accurate design.

As a system element, the valve is fail-safe in that it closed when power is removed, has low inertia for minimum overshoot and no mechanical linkages for minimum wear and maximum reliability.

METHOD FOR DRIVING PIEZOELECTRICALLY ACTUATED VALVES

Piezoelectrically actuated valves are employed for controlling small flows of gases. A notable example is the piezoelectrically actuated inlet valve, which is used for admitting gas to evacuated chambers at low, controlled rates. Such valves have been operated either by (1) a D.C. voltage (fixed), the level of which is adjusted to effect the desired opening, or by (2) duty cycle modulation (bang, bang). In duty cycle modulation, the drive voltage is switched between two extreme values at which two voltages the valve is fully closed and fully open respectively. Varying the proportion of time at the two voltage levels effects control.

Both of these drive methods have shortcomings. (1) With the D.C. operation (a) accurate control is difficult to achieve because of the hysteresis of the piezoelectric crystal and (b) when the valve opening is small, a D.C. controlled valve is susceptible to clogging by contaminants. (2) With duty cycle modulation, accurate control is readily achieved and there is a self-cleaning action, which reduces the likelihood of clogging. However, valves which are driven by duty cycle modulation are often short-lived because of the large, frequent voltage (and hence mechanical) excursions which are required for operation when the valve is pre-loaded to ensure sealing in the absence of an applied voltage.

A drive method for such valves having significant advantages is the saw-tooth method where the voltage applied to the piezoelectric crystal is relatively small amplitude triangular wave, which is superimposed upon an adjustable D.C. level. Control is effected by adjustment of the D.C. level. Operation of a piezoelectrically activated valve with this type of drive can be understood with reference to such a drive signal with gradually increasing D.C. level applied to a pre-loaded valve. While the D.C. level is low, the force generated in the crystal remains closed. At some point, as the D.C. level is increased, the force generated at the peaks of the triangular waves becomes just sufficient to overcome the pre-load and open the valve slightly for a very brief portion of each cycle. As the D.C. level increases further, both the amount and duration of opening in each cycle increase with increasing D.C. level. If the valve was controlled at this level the control would, in effect, be a combination of amplitude modulation and duty cycle modulation. Still further increases in D.C. level increase the amount and duration of valve opening in each cycle. However, the valve begins opening sufficiently far that further increases in the amount of opening do not significantly change the flow through the valve. Control in this regime closely resembles pure duty cycle modulation. Finally, at sufficiently high D.C. levels the valve goes beyond its control range and is open all of the time (as in duty cycle modulation with a 100% duty cycle).

This drive method retains advantages of duty cycle modulation in that valve function is readily controlled; and there is a self-cleaning action, which reduces the likelihood of valve clogging. Because the dynamic voltage excursion is much less than in duty cycle modulation, however, the life of the piezoelectric crystal and the valve seat are extended. In addition, the small dynamic excursion leads to a quieter operation than with duty cycle modulation.

Experience with this method of control has also shown that stable control is more easily achieved than with either duty cycle modulation or D.C. control.

PERFORMANCE PARAMETERS

The performance parameters of the valve are few in number and easy to interpret. The basic question is what flow can be obtained at a known pressure drop over the temperature extremes of the application. The valve has been characterized over the temperature range of plus 10° C to plus 60° C and a flow range of 0-500 SCCM at 1 atm. The valve will function at higher flow rates and temperature ranges and inquiries are welcome.

Figure 1 is data showing the effects of different threshold adjustments and temperature variations on performance. These performance curves must be considered when matching the valve to the system gain, controller drive range, maximum throughput over temperature and control resolution.

Figure 4 provides data showing power applied versus pressure.

APPLICATIONS

Typically, the valve is used with a flow meter to control gas flow or an ion gauge to maintain a high vacuum or installed in multiple lines as an on/off control in a gas mixing application. The list of applications includes but is not limited to the following:

1. Sputtering/Sputter Etching
2. Plasma Etching
3. Ion/Reactive Ion Milling
4. Diffusion Furnaces
5. Reactive Evaporation
6. Pressure Calibration Systems
7. Reactive Sputtering
8. Ion Beam Etching
9. Tube Backfilling
10. Ion Profiler
11. Mass Spectrometer
12. Tokamak Fusion Reactor

A piezoelectric valve has been modified and tested for pulsed operation and the data reported in industry journals.

MATERIALS

The following is a list of materials used in the MV-112 compared to Veeco's™ PV-10 valve, with properties of material reflected.

MAXTEK MV-112		
PART	MATERIAL	NOTES
Bottom Cover	304 SS	
Crystal Retainer	304 SS	
Retainer Screw & Washer	316 SS	
Bottom Cover Screw	316 SS	
Fittings (2)	316 SS	
Fittings O-Rings (2)	Viton	
Filter Spring	400 SS	M
Filter O-Ring	Viton	
Filter Element	316 SS	
Adjuster o-Ring	Viton	
Wire Insulation	Teflon	
Preload Ball	Teflon	
Preload Spring	400 SS	M
Spring Screw & Washer	316 SS	
Spacer O-Ring	Viton	
Bottom Cover O-Ring	Viton	
Main Housing	304 SS	
Piezo Element	Ceramic	
Bimorph Bonding	Epoxy	
Conductive Plating	Nickel	M **
Valve Seal Disk	Viton	
Valve Seat/Adjuster	304 SS	
Adjuster Spring	400 SS	M
Adjuster Housing	304 SS	
Adjuster Screw	316 SS	
Connector O-Ring	Viton	

M - Slightly Magnetic MM - Very Magnetic V - Poor High Vacuum Material ** Silver is Available

VEECO™ PV-10		
PART	MATERIAL	NOTES
Bottom Body (Cup)	304 SS	
Body Gasket	Viton	
Retainer Screw (2)	NP Brass	M
Retainer Spring	410 SS	M
Preload Button	Acrylic	V
Crystal Support	304 SS	
Piezo Element	Ceramic	
Conductive Plating	Silver	
Bimorph Bonding	Epoxy	
Valve Seal Disk	Viton	
Wire Insulation	Teflon	
Preload Spring	Blue Steel	MM, V
Spring Screw (3)	316 SS	
Locator Mastic	Silastic	V
Main Housing & Seat	304 SS	
Fittings (2)	316 SS	
Fitting O-Ring (2)	Viton	
Feedthrough Connector	Teflon	
Connector O-Ring	Viton	

M - Slightly Magnetic MM - Very Magnetic V - Poor High Vacuum Material ** Silver is Available

(Comparison of Piezoelectric Valve Materials)

COMPATIBILITY

Gases, such as Argon, that are dry and non-corrosive can be continuously exposed to the valve. Gases such as Chlorine, Ammonia and Hydrogen Sulfide will have a deleterious effect on the crystal and seal assembly in the valve. The valve has been used with radioactive tritium gas, with Viton seals replaced with EDPM.

MAGNETIC compatibility is a function of the material used in the construction of the valve and the effect of the magnetic property on the valve performance. The previous page lists the magnetically sensitive materials.

RELIABILITY

Warranty returns have been 0.5% or less for all valves shipped to date. The usual turn around time for returned valves is 48 hours. If the crystal needs replacement, the required burn-in and seating procedures extends this to 10 days maximum.