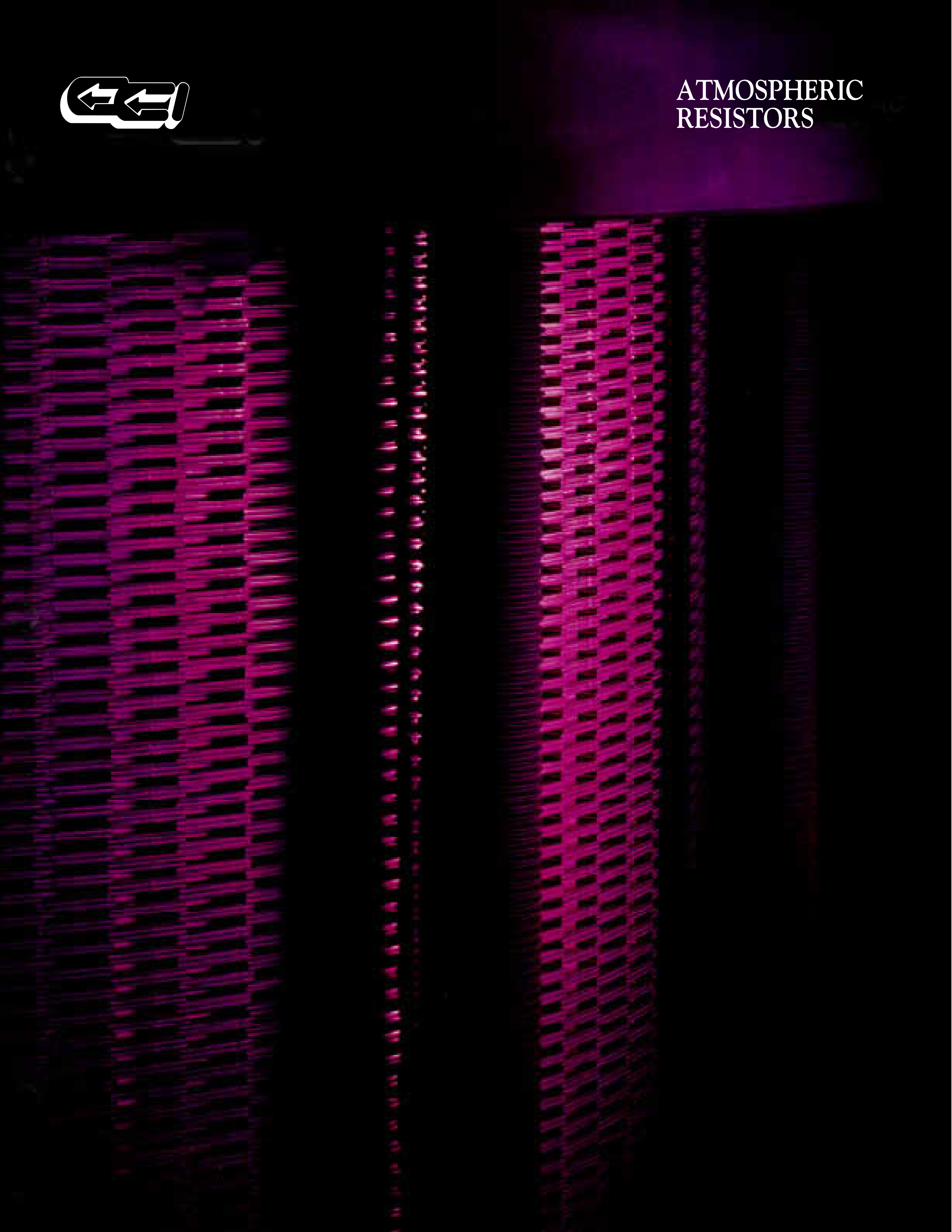
ATMOSPHERIC RESISTORS



INTRODUCTION

CCI Atmospheric Resistors are the best solution for applications where any gas or steam needs to be released to the atmosphere. Only a CCI Atmospheric Resistor prevents noise generation instead of muffling noise at the outlet. They can be used in applications involving a high pressure ratio, temperatures up to 1050°F (565°C), a low noise requirement, or where space is a problem. Atmospheric Resistors are versatile and may be used in series with a modulating valve or in series with an on/off valve. They are used in various applications such as protecting systems from over pressurization or discharging gas from systems. Atmospheric Resistors are designed simply and ruggedly consisting of a base flange, which supports a disk stack and a shroud. They are the most compact and economical solution to today s noise problems in atmospheric venting.

CCI ATMOSPHERIC RESISTORS -THE ONLY COMPLETE SOLUTION

The velocity control concept is independent of frequency. Each Atmospheric Resistor is custom designed to meet the specific requirements of your application. In addition to capacity, it is also sized to a low Mach number for quiet operation. It can be easily positioned with minimal supporting structure; since it is compact and lightweight. A CCI Atmospheric Resistor is the ideal solution to your atmospheric venting problems.

Typical Sizes

Flow Rate PPH **(kg/h)**	Disk Stack Dia. in (cm)	Base Flange Dia. in (cm)	Height in (cm)	Approx. Wt. lbs **(kg)**
26,000 (11,800)	16 (40)	32 (80)	20 (50)	1300 (590)
53,000 (24,000)	16 (40)	32 (80)	26 (66)	1600 (725)
82,000 (37,200)	16 (40)	32 (80)	32 (80)	1900 (860)
111,000 (50,400)	16 (40)	32 (80)	38 (96)	2200 (1000)
93,000 (42,200)	24 (60)	40 (100)	29 (73)	3300 (1500)
140,000 (63,500)	24 (60)	40 (100)	35 (90)	3900 (1770)
190,000 (86,200)	24 (60)	40 (100)	42 (106)	4500 (2040)
283,000 (128,400)	24 (60)	40 (100)	55 (140)	5700 (2590)

Note: Actual size may differ slightly depending on C_V, noise, and Mach number requirements.

DESIGNING TO THE CUSTOMER S NEEDS

The Atmospheric Resistor is a custom design, not a standard product line. Each Atmospheric Resistor is custom designed to individual specifications including material, capacity, pressure drop, and sound pressure level. Custom design guarantees that the end product is the best solution for your requirements, the most compact, and the most economical. Custom design does not imply that every part is redesigned for each order. Proven design concepts and parts are used on all orders. Parts are independently sized, not only to meet capacity specifications, but also to meet Mach number and noise constraints. Computer programs aid proposal and project engineers in detailed sizing and performance evaluation. Special testing and quality assurance requirements are welcomed.

TYPICAL APPLICATIONS

Safety Relief Valve Protection

Safety relief valves are the ultimate protection against rupturing pressure vessels and piping. Operation of these devices is generally avoided since they often cannot achieve tight shut-off upon closing, resulting in severe seat erosion. The system must be shut down to repair these valves. An on/off valve venting through an Atmospheric Resistor, set just below the relief valve set pressure allows a controlled, noise free pressure release. This solution reduces plant downtime for safety relief valve repair.

Blowdown

Tank or pipeline blowdowns are another common use for Atmospheric Resistors. An Atmospheric Resistor is attached to an on/off valve so the venting process does not subject the worker or surrounding community to high noise levels. If portability is a desired feature, the venting device can be designed portable enough to be carried along a pipeline. Atmospheric Resistors are compact and are designed to the customer s specified maximum allowable noise level. During the first few seconds of the blowdown, the noise level starts at this maximum; then decays to lower values. Pressure reduction occurs rapidly and blowdown time is short.

NOISE CONSIDERATIONS

Today s concern for industrial and community noise is increasing. Power plants and other industries are closer to populated areas. Most unsilenced venting devices cannot meet community noise restrictions. Even when there are no laws governing sound emissions, the nuisance factor causes local residents to continually complain to the plant operators until eventually something is done to eliminate the noise problem. In the United States, the Walsh-Healey Public Contracts Act and stricter OSHA standards are two examples showing how noise has become an important issue in industry today. Noise levels in the open areas of the plant can be over 100 dBA and OSHA compliance becomes a problem. Whenever there is a noise problem present, workers must wear ear plugs or head sets, which can be a nuisance. Verbal communications are hindered and accidents can occur because warnings are not heard properly. Prolonged exposure to high levels of noise can cause decreased efficiency and serious health problems, such as hearing loss.

Various methods are employed to solve the noise problem:

1. **Silencers or Mufflers**
   These devices are sections of ducts or pipes which have been shaped or treated with the intention of reducing the transmission of sound, while at the same time allowing the free flow of a gas. They are acoustical filters and performance is dependent upon frequency. They are designed to reduce noise levels at a particular frequency; but as the flow rate varies, the frequency at which the highest noise level occurs also varies. When this occurs, silencers become less desirable. Initial cost of silencers may be low; but frequently, due to the enormous size of the devices, supporting structures are required which can offset the potential savings. Also, space becomes a problem. For high pressure applications these devices become costly.

Typical Applications for CCI Atmospheric Resistors					
Inlet Pipe Size in	HtxBase Flange in (cm)	Inlet Press. psia (bar)	Plant Type	Application	Industry
2	6.5x6.5 (17x17)	374 (26)	Gas press. reducing	Igniter gas supply vent	Power
3	9x21 (23x53)	465 (32)	Methanol	Vent to atmos.	Petrochen
4	16.5x25 (42x64)	465 (32)	Methanol	Vent to atmos.	Petrochen
6	21.5x25 (55x64)	157 (11)	Power	Compressor	Power
10	23x35 (58x89)	90 (6)	Pulp and paper mill	Pressure relief	Petrochen
12	32x59.5 (81x151)	170 (12)	Nuclear power	Atmospheric dump	Power
16	53x80 (135x203)	385 (27)	Power	Hot reheat steam vent	Power
24	54x50 (137x127)	29 (2)	Power	Vent to atmos.	Power

2. **Diffusers**
   Most diffusers are pipes which have a multiplicity of small, drilled holes which cause the gas to exit radially. The primary effect of a diffuser is to divide the flow into many, small jets. Since the gas is sonic in each jet, high noise levels are still generated. If the surface of the shroud is close enough to the outside surface of the diffuser, condensates may impinge on the shroud.
3. **Position the noise source at a remote location**
   This can be very costly and is not always feasible.
4. **Build barriers or shields around the noise source to prevent personnel from coming near the source**
   Also very costly and not always feasible.
5. **Atmospheric Resistors**
   All these methods generate noise within the device, and then attempt to reduce noise levels by muffling the noise at the outlet. Only an Atmospheric Resistor prevents noise generation through velocity control. Velocity is the predominant factor in aerodynamic noise. The revolutionary design of the CCI disk stack prevents the gas from ever reaching sonic velocities. This unique approach to noise reduction is not dependent upon frequency or flow rate. The same high level of noise reduction will occur at fixed or varying frequencies and flow rates (see Figure 1).

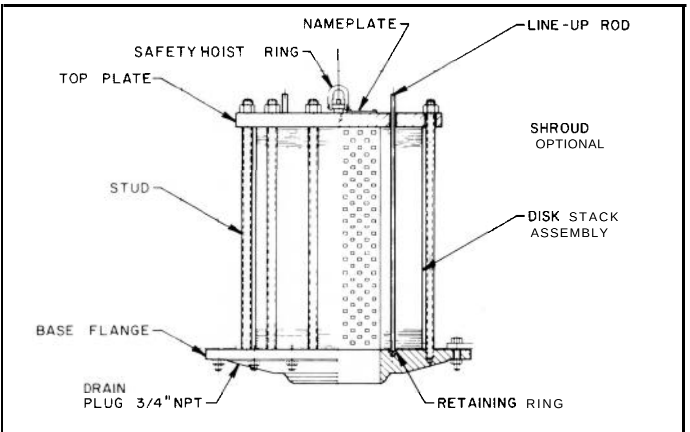


Figure I

A CCI Atmospheric Resistor is compact and lightweight, and therefore, does not require an extra supporting structure. It is the most cost effective solution to far field noise problems.

Definitions:

Aerodynamic *Noise*
This is the predominant type of noise in venting devices. It is caused by moving or unsteady compressible fluid flow and the interaction of moving compressible fluids with solid objects. Rapid expansion or deceleration of high velocity gas exiting the valve also causes this type of noise. The velocity of the gas and the extent of the turbulent area dictate the noise level. Factors affecting the level of this noise include the velocity of gas, upstream pressure, pressure drop, piping configurations, and the physical properties of the gas.

Attenuation
The reduction of the sound pressure level.

Directivity Index
An expression of directionality of a sound from a specific source, expressed in decibels. It is the difference between the sound pressure level measured in the far, free field and the sound source. This quantity varies with angle, given the same radius from the source. The shroud directs the sound upward. In general, as the angle increases downward from 90°, the sound intensity decreases (see Figure 2).

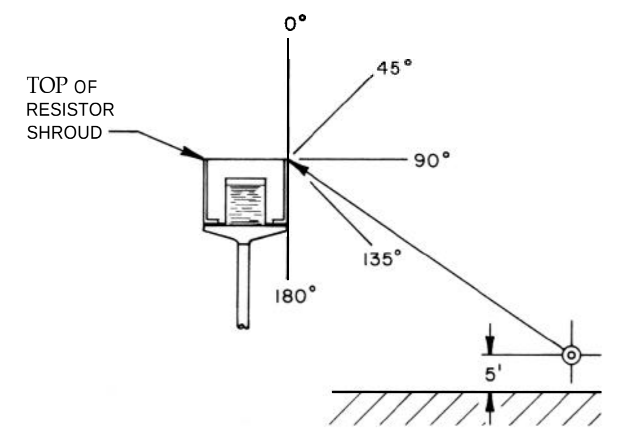


Figure 2

DIRECTIVITY INDEX

Angle from shroud axis, degrees	Directivity Index, dBA
0	0
20	+1
40	+8
60	+2
80	-4
100	-8
120	-11
140	-13
160	-15
180	-17

Far Field
This region consists of two parts, the free part and the reverberant part. In the free part, the sound pressure level obeys the inverse square law. In practice, this part may be approximated as being effective several wavelengths from the source, or several times the circumference of the source, choosing whichever is larger. Usually, this distance is 50 to 1000 feet (15 to 300m). The reverberant part of the far field exists for enclosed situations where the reflected sound waves are superimposed on the inci-

dent sound waves. If there are reflected waves from all possible directions, a diffuse sound field exists in which the acoustic energy per unit volume is essentially uniform throughout the room. This situation is sometimes found in industrial plants.

Free *Field*

Sound in a homogeneous, isotropic medium free from boundaries.

Inverse Square Law for Sound Intensity

If a sound source generates a fixed amount of sound power, the intensity decreases inversely as the square of the distance from the source. The equation for this relationship is:

$$I = \frac{W}{4\pi r^2}$$

Where I = sound intensity, watts/m2
W = sound power, watts
r = distance from sound source, m

Near Field

The region close to the source where the inverse square law does not apply. Usually this region is located within a few wavelengths of the source and is controlled by the dimensions of the source. In practice, the near field is 3 to 10 feet (1 to 3 m).

Noise Generation

The primary noise sources in venting devices are turbulent eddy interaction with surfaces inside the device, turbulent mixing, sonic shock waves, vibrations, unattenuated or partially unattenuated gas born noise generated upstream, and turbulent mixing of the exiting stream with ambient air (jet noise). The predominant source of noise is turbulence within the passage. This noise is proportional to velocity to the sixth power. The equation for total radiated sound power is:

$$W \propto \frac{\rho d^2 U^6}{C^3}$$

Where W = sound power
P = fluid density
d = characteristic dimension
U = fluid velocity
C = velocity of sound fluid

Note that the noise power generated by the gas is very much a function of the velocity. This velocity is controlled in an Atmospheric Resistor, so that minimum noise power is generated. This is the basic principle behind the outstanding performance of the Atmospheric Resistor.

Noise Attenuation and Directivity

An Atmospheric Resistor is a hemispherical radiation source with ground reflection. The effects of ground reflection are conservatively estimated at 3 dBA. The sound level heard by an observer in the far field is attenuated by directivity index, distance, and atmospheric conditions, such as molecular absorption, wind, and humidity. CCI accounts for attenuation due to the inverse square law and atmospheric absorption as shown in Figures 4 and 5. Another potential noise generator is the shroud. If it is not designed properly, the lip of the shroud produces a sound which is caused by the velocity of the gas passing across the lip. CCI recommends shroud dimensions to eliminate this noise source.

OPERATING PRINCIPLE OF THE DRAG@ DISK STACK

The basic principle of an Atmospheric Resistor is to control the velocity of the gas in such a way as to reduce the noise generated by the moving gas. Aerodynamic noise is produced when there is a rapid expansion of the gas from the inlet to the outlet. If the velocity between the inlet and outlet could be controlled, such that the gas would be allowed to expand gradually; then the noise generated by the expanding gas would be greatly reduced. In a CCI Atmospheric Resistor, this controlled expansion is accomplished with a series of expanding right angle turns inside the disk stack (see Figure 3). With each turn, the gas expands gradually as the pressure decreases from the inlet to the outlet. This eliminates the noise source due to rapid expansion. The expansion constant is precisely determined so that choked flow does not occur at any point. The velocity of the gas is controlled so that it is well below Mach 1 at all times. The noise

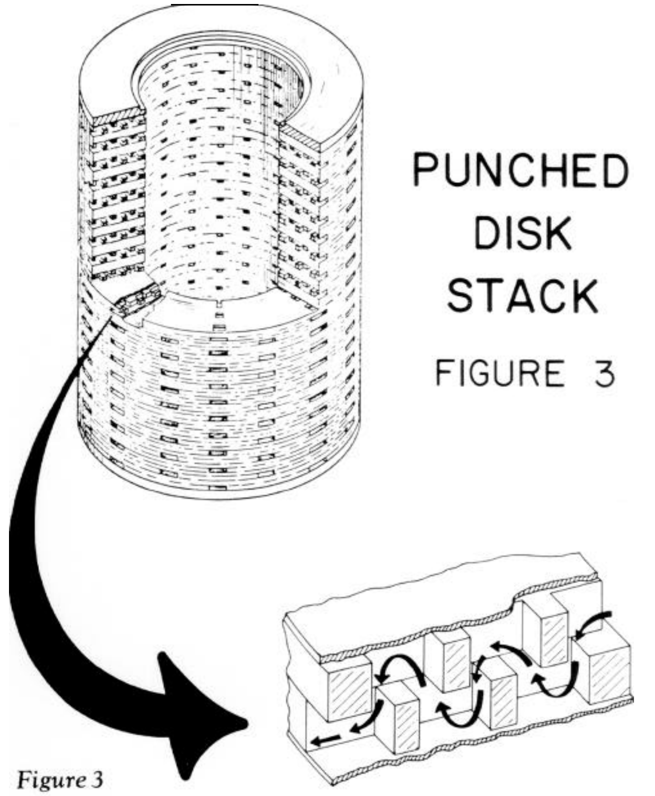
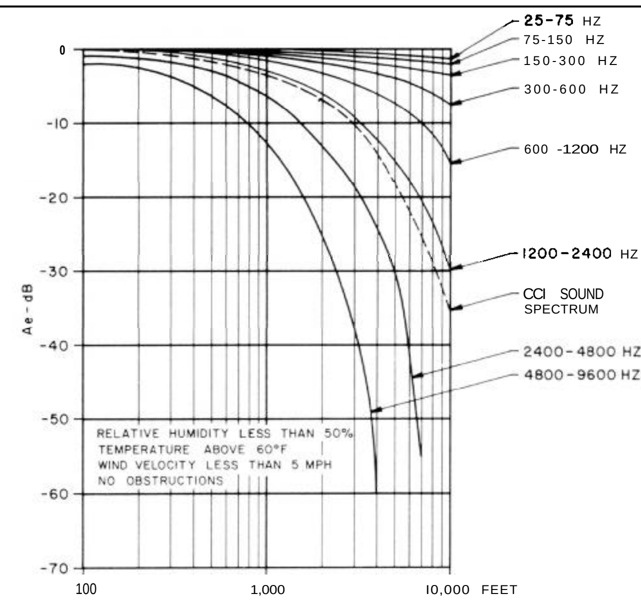


Figure 3

generated inside the disk stack is high frequency noise. When frequencies are converted to the A-weighted scale, higher frequencies are given a lower dBA value. The higher frequencies are subject to higher atmospheric absorption (see Figure 4).

As the noise is carried by the gas, part of it IS absorbed by the walls of the disk stack at each turn. A CCI disk stack prevents noise generation rather than attenuating noise at the outlet. It is a very effective means of reducing noise through velocity control.



APPROXIMATE CORRECTION FOR AIR ATTENUATION IN EXCESS OF THE INVERSE SQUARE LAW

Figure 4

FEATURES

1. **Inlet End Connection**
   An Atmospheric Resistor can be attached to any line. They can be welded in line or a flange connection can be added. If no end connection is specified, then a weld connection per ANSI B16.25 is manufactured.
2. **Safety Hoist Ring**
   An eyebolt is attached to the top of the Atmospheric Resistor to aid in the installation and possible moving of the device.
3. **Drain Plug**
   In some cases, condensation may accumulate inside the shroud of the Atmospheric Resistor because of the difference in temperature between the escaping gas and the shroud. A pipe connection is provided so that this excess liquid may be drained.
4. **Shroud**
   A shroud can be used to prevent the escaping gas from contacting surrounding machinery and personnel. The purpose of the shroud is to redirect the flow and noise. It does not serve as an attenuator or pressure vessel and therefore, is lightweight. The base flange includes a bolting pattern so that a shroud may be added to the resistor. CCI will supply a shroud, at the customer s option, which does not cause regenerated noise. This assembly is bolted to the base flange and a gasket is used between the base flange and the assembly to prevent gas from escaping and becoming another possible source of noise.
5. **Materials**
   CCI will build an Atmospheric Resistor using virtually any material required for your particular application. In most applications the base flange is a casting.

ADVANTAGES IN USING A CC1 ATMOSPHERIC RESISTOR

1. **Custom Design**
   Each Atmospheric Resistor is custom designed to meet the individual specifications of your particular application and noise requirement. Atmospheric Resistors cover a broad range of capacities. Each disk in the stack has a certain capacity and the total Cv of the resistor is the summation of the Cv of each individual disk. Therefore, a resistor with any amount of Cv can be designed by simply increasing or decreasing the number of disks. Cv s are as small as 35 and as large as 2282.
2. **Versatility**
   A valve in series with an Atmospheric Resistor may be located conveniently in the piping system, such as an inline control valve, while the Atmospheric Resistor may be located conveniently on the roof away from an area where personnel may be working.
3. **Compact Design**
   Compact design requires minimum space for installation. Typical sizes vary from 32 to 60 inches (80 to 155 cm) in diameter and 20 to 55 inches (50 to 140 cm) in height. For mufflers and silencers to provide the comparable noise reduction, they need to be two to seven times longer and two to four times larger in diameter.
4. **Economy**
   An Atmospheric Resistor solves the noise problem and no additional costs are added after installation to reduce noise to acceptable levels. No acoustic lagging is needed.
5. No **Maintenance**
   The simple design of an Atmospheric Resistor does not include parts which need replacement.
6. **Lightweight**
   Since an Atmospheric Resistor is compact in size and lightweight, it does not require extra supporting structure.
7. **Single Vendor**
   The total package is from a single vendor. One company may be contacted for service and support.

CCI-EXPERTS IN THE VALVE INDUSTRY

Since 1961, CCI has been solving problems for a diverse group of industries. Our unique solutions to the problems of cavitation, noise, and erosion have made us leaders in the valve industry. CCI employs experts in all of the appropriate fields in order to find the best solution for your needs. Talk to a sales representative to find out how CCI can help solve your problems.

Typical Shroud Sizes

Flow rate PPH	(kg/h)	Diameter in	(cm)	Height in	(cm)	Approx. wt. lbs	(kg)
26,000	(11,800)	32	(80)	14	(35)	150	(70)
53,000	(24,000)	32	(80)	14	(35)	150	(70)
82,000	(37,200)	34	(86)	20	(50)	200	(90)
111,000	(50,400)	42	(107)	26	(66)	375	(170)
93,000	(42,200)	42	(107)	14	(35)	200	(90)
140,000	(63,500)	46	(117)	20	(50)	300	(135)
190,000	(86,200)	60	(152)	38	(96)	800	(365)
283,000	(128,400)	60	(152)	38	(96)	800	(365)

Typical Materials

Part Name	Up to 800°F (427°C)	800°F to 1050°F (565 °C)
Top Plate	A105	A182-F11
Base Flange	A216-WCB	A217-WC6
Studs	A193-B7	A193-B16
Nuts	A194-2H	A194-3
Line-Up Rods	416 SS	416 SS
Disk Stack	410 ss	410 ss

Nomenclature

Ae	Air noise absorption, dBA (see Figure 3)
C_v	Required flow capacity
DI	Directivity index, dBA (refer to Table 3)
Db	Bottom shroud diameter, in. (cm.)
Di	Disk stack inner diameter, in. (cm.)
Do	Disk stack outer diameter, in. (cm.)
Dt	Top shroud diameter, in. (cm.)
H	Disk stack height, in. (cm.)
N	Number of turns
P	Inlet pressure, psia (kPa)
PA	Atmospheric pressure, 14.7 psia (101.4 kPa)
RFF	Far field distance, ft. (m)
R	Disk stack resistance factor, dimensionless
SPL	Far field sound pressure level, dBA
W	Flow rate, lbm/h (kg/h)
Y	Compressible flow factor, dimensionless
ρ	Inlet density, lbm/ft3 (Kg/m3)

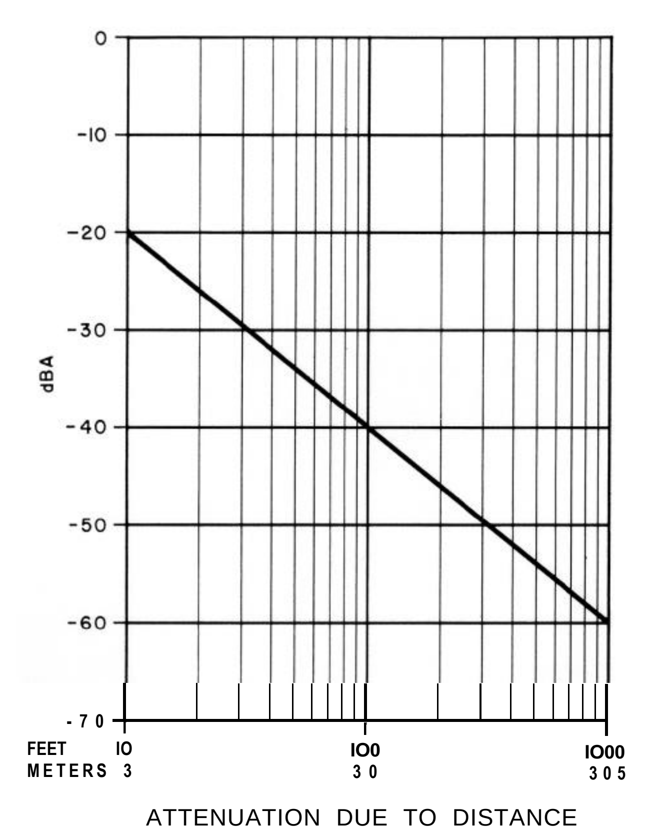


Figure 5

SIZING PROCEDURE FOR ATMOSPHERIC VENTING ELEMENTS

1. Calculate the required capacity constant, Cv.

English:

$$Cv = \frac{.016\,W}{Y\sqrt{\rho\,(P-P_A)}}$$

Metric:

$$Cv = \frac{.366\,W}{Y\sqrt{\rho\,(P-P_A)}}$$

Where:

$$Y = \sqrt{\frac{P+P_A}{2P}}$$

2. Calculate the required inner diameter of the disk stack as the maximum value of either: 84% of the required upstream pipe (refer to CCI's Valve Noise bulletin for details of sizing the upstream pipe), or

English:

$$\sqrt{.0424\,C_v}$$

Metric:

$$\sqrt{.274\,C_v}$$

Round this value up to the nearest standard size: 3,4,6,8, or 12 in. (7.6, 10.2, 15.2, 20.3, or 30.5 cm.). These requirements assure that the disk stack inner diameter will not restrict capacity, and will not result in excessive noise generation.

3. Determine the required number of turns, through trial and error, to satisfy the following equation:

English:

$$SPL = 10\log W - 18.5\log[N(1.072)^N] - 20\log R_{FF} + DI - A_e + 18\log P + 10\log\rho + 86$$

Metric:

$$SPL = 10\log W - 18.5\log[N(1.072)^N] - 20\log R_{FF} + DI - A_e + 18\log P + 10\log\rho + 52$$

4. Using Figure 6, check that the selected turns allow the Mach number to fall between 0.2 and 0.9. If the number of turns is below the 0.9 requirement, select the number of turns from Figure 6 to meet the 0.9 requirement. If the number of turns is greater than the Mach 0.2 requirement, select the number of turns to meet the 0.2 level. Tests have shown that little noise reduction is achieved below Mach 0.2, so the additional turns are unnecessary. This does mean that the actual noise level will exceed the requirement. The predicted noise level can be calculated using the equation in step 3, above.

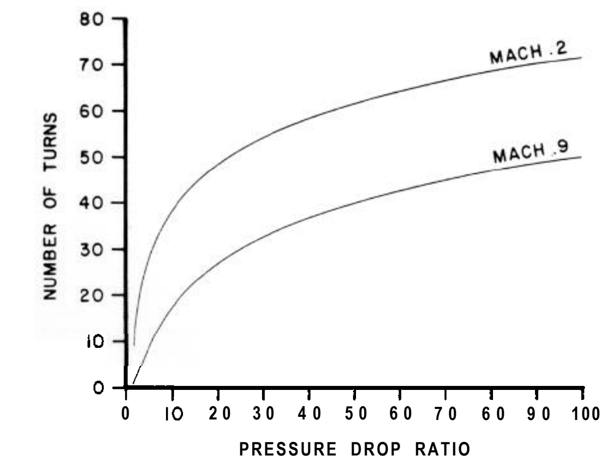


Figure 6

5. Calculate the disk stack outer diameter:

English:

$Do = Di + .25\ N$

Metric:

$Do = Di + .64\ N$

Round this value up to the nearest standard size: 15.5 in. (39.4 cm.), 23.5 in. (59.7 cm.). If Do is greater than the largest size, consult the factory.

6. Calculate the disk stack height using the following equation, and the disk stack resistance factor, R, from Table 1:

English:

$$H = \frac{CvR}{Do}$$

Metric:

$$H = \frac{6.45\,C_v R}{Do}$$

Round this upward to the nearest standard height: 6,9, 12, 18, 24, or 36 in. (15.2, 22.8, 30.5,45.7, 61.0, or 91.4 cm.).

7. The minimum dimensions for the shroud that may be optionally placed around the disk stack vent are given in Table 2. Db is the diameter of the shroud surrounding the vent. Above the disk stack vent, the shroud is allowed to narrow, since the disk stack is no longer partially occupying the outlet flow area. Dt is the minimum required diameter of the extended shroud.

Table 1

Disk Stack Resistance Factor, R					
Turns	R	Turns	R	Turns	R
Ø	.024	34	.686	68	7.226
2	.044	36	.789	70	8.358
4	.061	38	.907	72	9.601
6	.078	40	1.042	74	11.030
8	.096	42	1.198	76	12.670
10	.115	44	1.376	78	14.555
12	.137	46	1.581	80	16.720
14	.161	48	1.817	82	19.208
16	.188	50	2.088	84	22.065
18	.219	52	2.398	86	25.357
20	.254	54	2.755	88	29.118
22	.293	56	3.165	90	33.449
24	.339	58	3.637	92	38.425
26	.391	60	4.178	94	44.141
28	.450	62	4.799	96	50.707
30	.518	64	5.513	98	58.250
32	.596	66	6.333	100	66.915

Table 2

Minimum Shroud Sizes, in. (cm.)				
	Stack Outer Diameter			
	15.5 (39.4)		23.5 (59.7)	
Height	Db	Dt	Db	Dt
6 (15.2)	25 (63.5)	14 (35.6)	34 (86.4)	19 (48.3)
9 (22.8)	28 (71.1)	19 (48.3)	37 (94.0)	23 (58.4)
12 (30.5)	29 (73.7)	21 (53.3)	39 (99.1)	27 (68.6)
18 (45.7)	33 (83.8)	26 (66.0)	43 (109)	32 (81.3)
24 (61.0)	37 (94.0)	31 (78.7)	47 (119)	37 (94.0)
36 (91.4)	43 (109)	38 (96.5)	54 (137)	46 (117)

ATMOSPHERIC VENTING ELEMENT DATA SHEET

CUSTOMER	ULTIMATE CLIENT	PROJECT

STATION	UNIT	SERVICE

TAG NUMBER	QUANTITY	MODULATION? ☐ YES ☐ NO	CCI SHROUD? ☐ YES ☐ NO

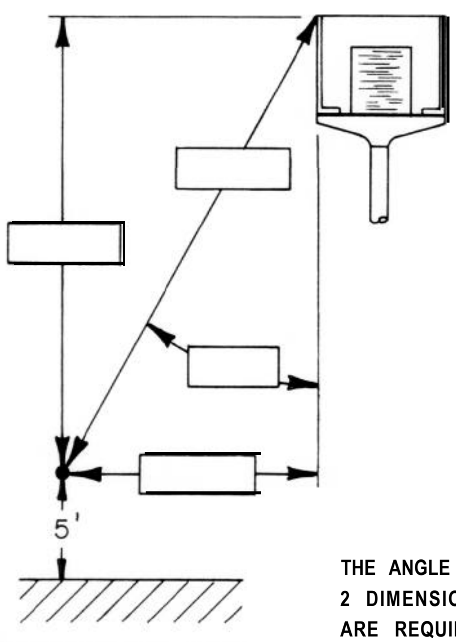
INLET PIPE NOMINAL SIZE SCH.	THERMAL LAGGING? ☐ YES ☐ NO	INLET CONNECTION ☐ WELDED ☐ FLANGED

SERVICE CONDITIONS:

FLUID	UNITS	COND. 1	COND. 2	COND. 3	COND. 4	COND. 5	COND. 6
FLOW RATE							
INLET PRESSURE							
PRESS. DROP (△P)							
INLET TEMPERATURE							
FLUID PROPERTY							
NEAR FIELD SOUND PRESSURE LEVEL	dBA@	dBA@	dBA@	dBA@	dBA@	dBA@	dBA@
FAR FIELD SOUND PRESSURE LEVEL	dBA@	dBA@	dBA@	dBA@	dBA@	dBA@	dBA@

DESIGN PRESSURE	DESIGN TEMPERATURE

DIRECTIVITY INDEX



THE ANGLE OR 2 DIMENSIONS ARE REQUIRED.

COMPLETE THIS SECTION IF MODULATION IS REQUIRED

ACTUATOR	POSITIONER	TRAVEL TIME
TYPE	TYPE	SEC. OPEN SEC. CLOSE
HANDWHEEL	INPUT SIGNAL	SEAT LEAKAGE ANSI 816.104
POWER SUPPLY	INCREASING SIGNAL	ACCESSORIES
FAILURE POSITION		

NOTES/SPECIAL INSTRUCTIONS

We Solve Control Value Problems

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