Engineering Information

SPECIFYING SPRAY NOZZLES

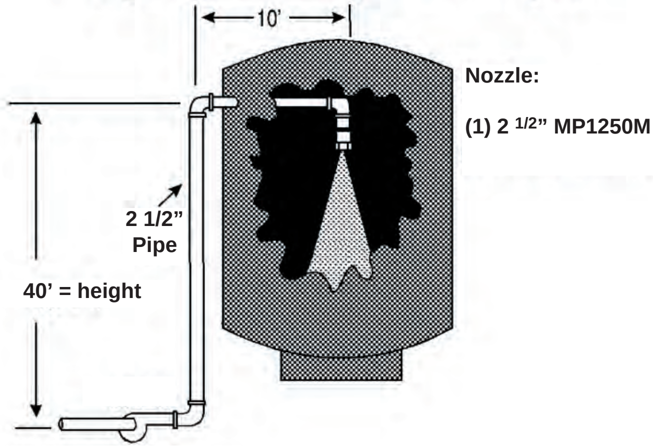
Spray nozzles have three basic functions:

- meter flow
- distribute liquid
- break up a liquid stream into droplets

The process of choosing a nozzle includes specifying:

a.) its flow-rate-versus-pressure characteristics (see catalog flow rate tables)
b.) how the droplets will be distri-buted after leaving the nozzle (see spray pattern, pp. 2, 3)
c.) the size of the droplets that will be produced (contact BETE Applications Engineering if droplet size is critical)
d.) the nozzle connection to the feed pipe (see dimension tables)
e.) the material of construction (see page 12 for complete list)

System Design Example



Calculate Total Water Flow and Pressure at Pump for Nozzles Operating at 7 PSI

Total Flow *(pp. 38, 39)* = (1 nozzle)(99 GPM/nozzle) = **99 GPM**

Pump Pressure Formula:

$$P_{pump} = P_{nozzle} + P_{pipe\ losses} + \rho h/144$$

Pipe Friction: (50')(3.09 PSI/100') = 1.6 PSI
Fitting Loss: (3 elbows)(5'/elbow) = 15'
(15')(3.09 PSI/100') = 0.5 PSI
Total Piping Losses: 1.6 PSI + 0.5 PSI = **2.1 PSI**
Elevation Losses: (62.4)(40')/ 144 = **17.3 PSI**

P_{pump} = 7 PSI + 2.1 PSI + 17.3 PSI = 26.4 PSI

Pump must be sized to provide 99 GPM at 26.4 PSI

FLOW RATE

The volume of liquid flowing through a nozzle depends primarily on the difference in fluid pres-sure upstream of its orifice and the pressure into which the nozzle discharges (normally that of the at-mosphere). Pressures that are listed in the flow rate tables of each nozzle series are *gauge pressures.*

Flow rates for pressures not tabulated may be calculated using the equation given at the bottom of each table. The factor "K" is listed for each nozzle and has units of gpm ÷ PSI^x.

A nozzle may discharge into a vessel where the pressure is not atmospheric. Since the nozzle flow rate is determined by the *differential* pressure across it, the flow rate may be calculated by subtracting the gauge pressure inside the vessel from the gauge pressure at the nozzle inlet as shown:

$$GPM = K\,(PSI_{Inlet} - PSI_{Vessel})^{x}$$

FLUID PROPERTIES

Specific gravity primarily affects nozzle flow. Flow rates of liquids denser than water are lower than flow rates of water at the same pressure because more energy is required to accelerate denser fluids. The following relationship exists between flow rates (Q) of fluids with different specific gravities:

$$\frac{Q_2}{Q_1} = \sqrt{\frac{SG_1}{SG_2}}$$

FLUID PROPERTIES
(at room temperature)

Fluid	Viscosity	Specific Gravity
Water	1cP	SG=1
10W-30 Oil	110 cP	SG=0.88
Honey	1500 cP	SG=1.05

Viscosity also affects nozzle performance. High viscosities inhibit atomization. In general, fluids with viscosities greater than 100 cP are difficult to atomize except with air atomizing nozzles.

SYSTEM DESIGN

The piping system that supplies the nozzles must be designed to deliver the correct pressure at the nozzle inlet.

The following formula is useful in estimating the pressure a pump will have to supply to a nozzle system:

$$P_{Pump} = P_{Nozzle} + P_{Pipe\ Losses} + \frac{\rho\, h}{144}$$

where:
ρ = density of fluid (lbm/ft^3)
[water = 62.4 lbm/ft^3]
h = height of nozzle above pump (ft) - negative if the nozzle is below the pump
P = pressure (PSI)

A chart of pipe friction losses is presented on page 127. In using the chart be sure to look at the *total* system flow if there are multiple nozzles to be supplied by one pipe. Elbows, tees and other pipe fittings (p. 127) also contribute to pressure loss and can be significant, especially in short, convoluted runs.

SPRAY ANGLE

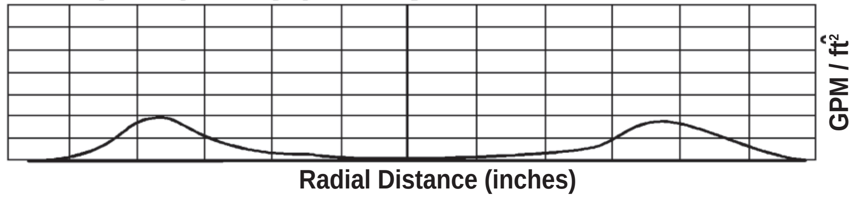
The spray angle chosen for a particular application depends on the coverage required.

The spray angle for spiral nozzles is relatively stable over a wide range of pressures, while the spray angle for whirl nozzles tends to decrease as the pressure is increased. For additional information see page 126.

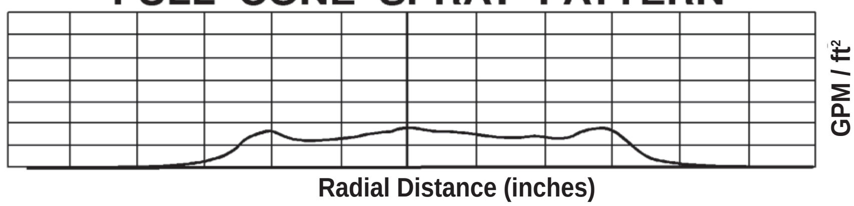
NOZZLE SPRAY PATTERN

The term "Spray Pattern" describes the location and spray density of the liquid emitted from a nozzle.

HOLLOW CONE SPRAY PATTERN



FULL CONE SPRAY PATTERN



Two examples of pattern measurement are shown above. The height of the curve at any point is the spray density in units of GPM/ft^2.

DROPLET SIZE

Droplet size is often critical. Many processes such as gas scrubbing depend on exposing the maximum possible amount of liquid surface to a gas stream. Other applications require that the droplets be as large as possible, such as when the spray must project into a fast moving gas stream.

Exposing the maximum surface area requires breaking the liquid into droplets as small as possible. To get an idea of how this works, imagine a cube of water with a volume of 1 gallon. This cube has a surface area of 1.6 ft^2. If we now split it in two, we expose some of the inner surface and increase the total surface area to 2.1 ft^2.

Atomizing the liquid into spheres 1 mm (1,000 microns) in diameter would increase the surface area of this gallon of liquid to 244 ft^2.

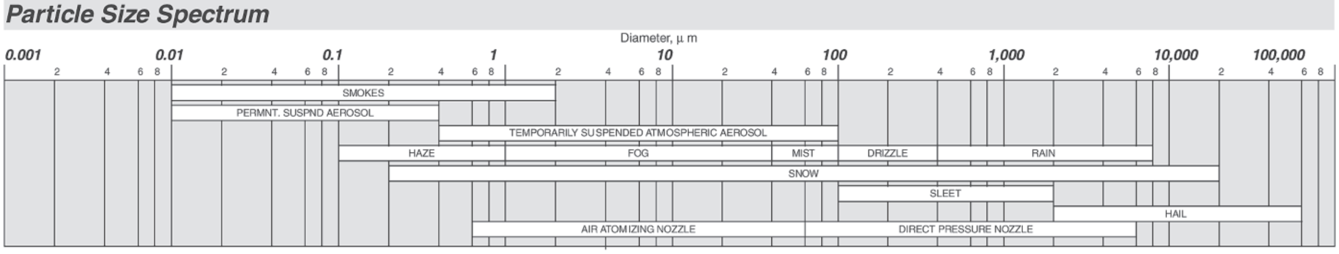
A nozzle actually produces a range of droplet sizes from the solid liquid stream. Since it is inconvenient to list all the sizes produced, droplet size (in microns) is usually expressed by a mean or median diameter.
An understanding of diameter terms is essential.

The following definitions are given for the most frequently used mean and median diameters:

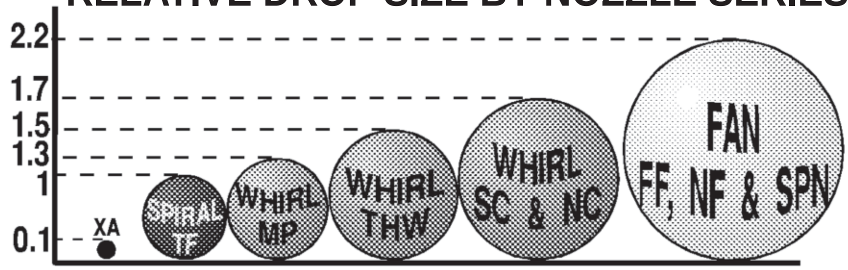
Arithmetic Mean Diameter (D_{10}):
- The average of the diameters of all the droplets in the spray sample.

Volume Mean Diameter (D_{30}):
- The diameter of a droplet whose volume, if multiplied by the total number of droplets, will equal the total volume of the sample.

Particle Size Spectrum



RELATIVE DROP SIZE BY NOZZLE SERIES



Sauter Mean Diameter (D_{32}):

- The diameter of a droplet whose ratio of volume to surface area is equal to that of the complete spray sample.

Mass (Volume) Median Diameter (DV_{05}):

- The diameter which divides the mass (or volume) of the spray into two equal halves. Thus 1/2 of the total mass is made up of droplets with diameters smaller than this number and the other half with diameters that are larger.

The Sauter Mean Diameter is one of the most useful ways to characterize a spray. The ratio of volume to surface area for the Sauter Mean is the same as that ratio for the entire spray volume. For this reason, the use of the Sauter Mean is preferred for process calculations.

Whirl nozzles generally produce larger droplets than spiral nozzles, and air-atomizing nozzles such as the XA or SpiralAir Series typically produce the smallest droplets of all.

It is sometimes useful to predict the effect a change in pressure will have on the droplet size produced by the nozzle. For single fluid nozzles the following equation may be used for modest changes in pressure:

$$\frac{D_2}{D_1} = \left(\frac{P_2}{P_1}\right)^{-0.3}$$

TROUBLESHOOTING BASICS

The following are some of the things to look for when a system is not performing as intended:

Nozzle Wear or Corrosion

- may cause excessive flow rate due to enlarged passages
- may increase droplet size
- degrades spray pattern

Nozzle Clogging

- low flow rates
- poor spray pattern

Inadequate Pipe Size

- excessive pipe pressure losses leading to low nozzle pressures
- high velocities in headers that disrupt fluid entering the nozzle

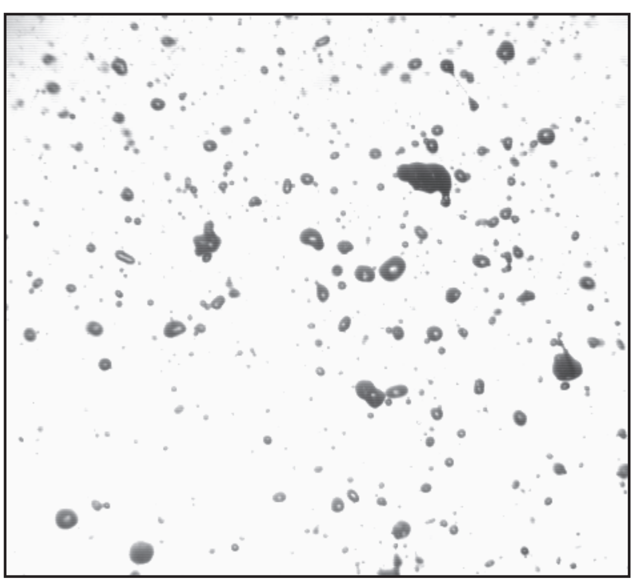
Incorrect Nozzle Location

- poor gas/liquid contact in scrubbers and quenchers
- poor area coverage

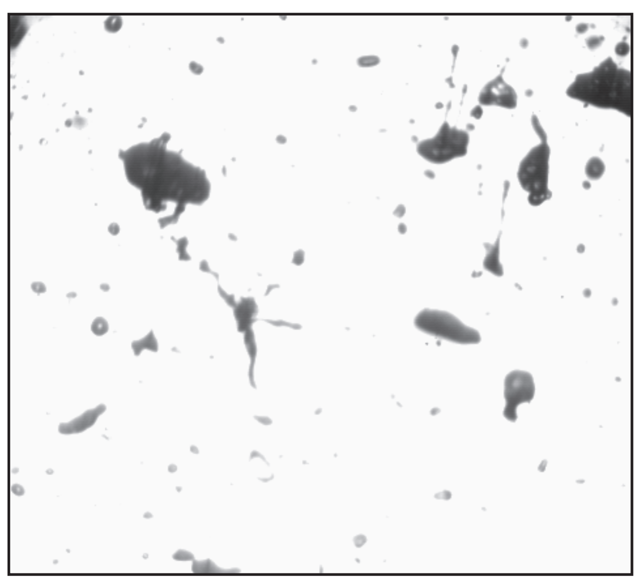
Incorrect Nozzle for Application

- drop size too small or too large
- incorrect pattern type

Careful system design and selection of the proper BETE nozzle will minimize spray problems.



Actual droplet images captured using the BETE Model 700 Spray Analysis System.



The BETE Droplet Analyzer is capable of characterizing non-spherical droplets like those seen in this actual image.

Research & Development

RESEARCH & DEVELOPMENT
BETE's state-of-the-art **Spray Laboratory** (details on page 16) plays a key role in supporting both product R&D and our customer service network.

Equipped with sophisticated video-image processing, CFD, and digital analysis technology, the Spray Lab makes possible rapid nozzle development and evaluation.

The Spray Lab is also available on a contract basis to provide confidential, quantitative evaluation of nozzle performance. Industrial applications for contract testing range from comparative nozzle performance testing to development of proprietary designs. These capabilities allow our customers to optimize process performance while minimizing capital and operating costs—a winning combination in today's competitive global marketplace.

Spray Laboratory Capabilities

- Flow rate (water) measurements from 0.01 to 2000 gpm
- Flow rate (air) measurements to 3000 scfm
- Pressure measurements to 10,000 psi
- Automated drop size distribution measurement from less than 2 to greater than 15,000 microns
- Computerized spray distribution analysis
- Two-fluid capabilities up to 3000 scfm air / 2000 gpm water
- 30′ x 50′ x 22′ high test area

DROPLET ANALYSIS
Frustrated by the limited capabilities of laser-based instruments, BETE developed the Model 700 Video Particle Analyzer. This flexible system allows BETE to characterize the difficult sprays containing significant numbers of large and non-spherical drops often encountered in industrial applications. The Model 700 is a video-imaging system combining a CCD video camera, microscope lens, fast strobed xenon light source, and image processing hardware and software running on a host PC-compatible computer.

PATTERN DISTRIBUTION ANALYSIS
The BETE Patternator is a unique digital video system for accurately analyzing the volumetric distribution of liquid emitted from a nozzle. The system uses a standard tube patternator combined with BETE's custom shape recognition and timing software. From this digitized information, spray density and effective spray angles are calculated. Because data collection and analyses are handled by a computer, the device is very well-suited for handling the large amount of data required for nozzle development and assessment programs.

Consistently and accurately selecting appropriate sampling positions is extremely important when performing drop size analysis. The challenge lies in sampling the spray in such a way that the number and locations of the individual tests chosen present a reasonable representation of the entire spray. Recognizing this, BETE has integrated the patternator with the Model 700 analyzer on a calibrated X-Y-Z positioner and developed a number of sampling protocols for droplet size analysis. These protocols ensure that the reported drop size distributions most accurately reflect the overall spray performance, thus allowing a high degree of repeatability and confidence.

COMPUTER MODELING AND SIMULATION
There are instances when duplicating the operating environment in the spray lab is impossible. When the nozzle is to be used in a high-temperature or pressure environment or sprayed in a high velocity gas stream, BETE Applications Engineers use computer modeling and simulation software developed in-house to assist in specifying the proper nozzle.

Spray-modeling has also been used to predict spray behavior in HF mitigation systems and to specify nozzles and layouts on off-shore drilling platforms. Other applications include predicting spray drift from cooling ponds and dust suppression systems and estimating evaporation rates from disposal ponds.

Working with engineering companies and consulting groups, BETE Engineering taps this modeling and simulation technology to offer customized spray nozzle solutions to some of the most vexing problems facing today's industries.

INDUSTRY COOPERATIVE DEVELOPMENT PROGRAMS
BETE has worked closely with major industries in research and development programs addressing personnel safety and environmental protection issues.

BETE has provided technical expertise, computer simulation, testing, and nozzle prototypes in a variety of projects, including:

- fire control aboard offshore drilling platforms
- toxic gas control
- oil spill cleanup
- reducing CFC use in the semi-conductor industry

Spray Coverage

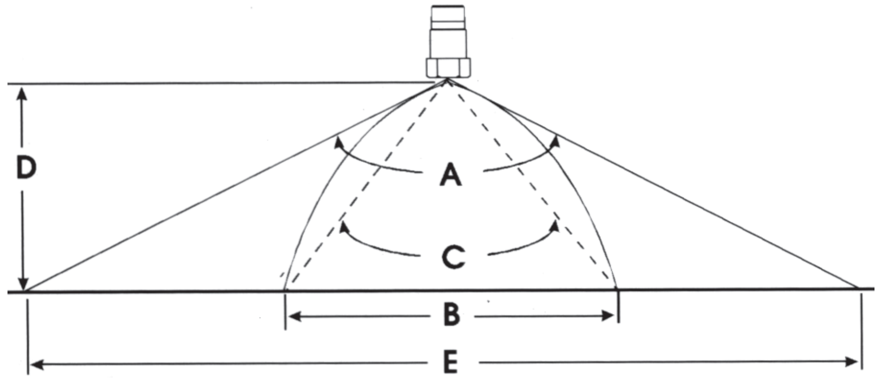
SPRAY ANGLE TERMS
Four terms are commonly used to describe spray coverage:

Spray Angle:
(A) The included angle of the spray as measured close to the nozzle orifice. Since the droplets are immediately acted upon by external forces (gravity and moving gases, for example), this measurement is useful only for determining spray coverage close to the nozzle. The spray angles lis-ted for nozzles in this catalog are angles at the nozzle, measured at the nozzle's design pressure, which is highlighted in each chart of flow rate vs. pressure.
Actual Spray Coverage:
(B) The actual coverage at a speci-fied distance **(D)** from the nozzle.
Effective Spray Angle:
(C) The angle calculated from the actual coverage **(B)** at a distance **(D)**.
Theoretical Spray Coverage:
(E) The coverage at distance **(D)** if the spray moved in a straight line.

EXAMPLES:
Problem: To achieve a 10″ diameter spray coverage from a nozzle mounted 15″ from the target, what spray angle would be required?
Solution: 40° Spray Angle

Problem: How far from the target should a nozzle with a 110° spray angle be mounted in order to achieve a 36″ diameter spray?
Solution: Approximately 15″. (Actual coverage will be less than theoretical coverage listed in the table.)

NOTE: *For applications where coverage is critical, contact BETE Applications Engineering using the Application Intake Form on page 130.*



THEORETICAL SPRAY COVERAGE (E) IN INCHES

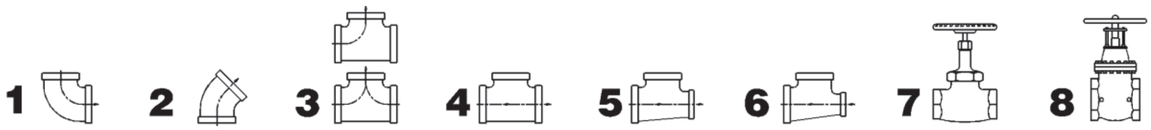
Included Spray Angle (A)	Distance From Nozzle Orifice (D) (inches) 2	4	6	8	10	12	15	18	24	30	36
10°	0.4	0.7	1.1	1.4	1.8	2.1	2.6	3.1	4.2	5.2	6.3
20°	0.7	1.4	2.1	2.8	3.5	4.2	5.3	6.4	8.5	10.6	12.7
30°	1.1	2.1	3.2	4.3	5.4	6.4	8.1	9.7	12.8	16.1	19.3
40°	1.5	2.9	4.4	5.8	7.3	8.7	10.9	13.1	17.5	21.8	26.2
50°	1.9	3.7	5.6	7.5	9.3	11.2	14.0	16.8	22.4	28.0	33.6
60°	2.3	4.6	6.9	9.2	11.5	13.8	17.3	20.6	27.7		
70°	2.8	5.6	8.4	11.2	14.0	16.8	21.0	25.2	33.6		
80°	3.4	6.7	10.1	13.4	16.8	20.2	25.2	30.3	40.3		
90°	4.0	8.0	12.0	16.0	20.0	24.0	30.0	36.0	48.0		
100°	4.8	9.5	14.3	19.1	23.8	28.6	35.8	43.0			
110°	5.7	11.4	17.1	22.8	28.5	34.3	42.8	51.4			
120°	6.9	13.9	20.8	27.7	34.6	41.6	52.0	62.4			
130°	8.6	17.2	25.7	34.3	42.9	51.5	64.4				
140°	10.9	21.9	32.9	43.8	54.8	65.7					
150°	14.9	29.8	44.7	59.6	74.5						
170°	45.8	91.6									

NOTE: Data shown is theoretical and does not take into consideration the effects of gravity, gas flow, or high pressure operation.

Water Flow Data

FLOW OF WATER THROUGH SCHEDULE 40 STEEL PIPE

Discharge		Pressure Drop per 100 feet and Velocity in Schedule 40 Pipe for Water at 60° F															
		Velocity	Press. Drop	Velocity	Press. Drop	Velocity	Press. Drop	Velocity	Press. Drop	Velocity	Press. Drop	Velocity	Press. Drop	Velocity	Press. Drop	Velocity	Press. Drop
Gallons per Minute	Cubic Ft. per Second	feet per Second	Lbs. per Sq. In.	feet per Second	Lbs. per Sq. In.	feet per Second	Lbs. per Sq. In.	feet per Second	Lbs. per Sq. In.	feet per Second	Lbs. per Sq. In.	feet per Second	Lbs. per Sq. In.	feet per Second	Lbs. per Sq. In.	feet per Second	Lbs. per Sq. In.
		1/8"		1/4"		3/8"		1/2"									
0.2	0.000446	1.13	1.86	0.616	0.359												
0.3	0.000668	1.69	4.22	0.924	0.903	0.504	0.159	0.317	0.061	3/4"							
0.4	0.000891	2.26	6.98	1.23	1.61	0.672	0.345	0.422	0.086								
0.5	0.00111	2.82	10.5	1.54	2.39	0.840	0.539	0.528	0.167	0.301	0.033						
0.6	0.00178	3.39	14.7	1.85	3.29	1.01	0.751	0.633	0.240	0.361	0.041						
0.8	0.00178	4.52	25.0	2.46	5.44	1.34	1.25	0.844	0.408	0.481	0.102	1"		1 1/4"			
1	0.00223	5.65	37.2	3.08	8.28	1.68	1.85	1.06	0.600	0.602	0.155	0.371	0.048			1 1/2"	
2	0.00446	11.29	134.4	6.16	30.1	3.36	6.58	2.11	2.10	1.20	0.526	0.743	0.164	0.429	0.044		
3	0.00668			9.25	64.1	5.04	13.9	3.17	4.33	1.81	1.09	1.114	0.336	0.644	0.09	0.473	0.043
4	0.00891	2"		12.33	111.2	6.72	23.9	4.22	7.42	2.41	1.83	1.49	0.565	0.858	0.150	0.630	0.071
5	0.01114					8.40	36.7	5.28	11.2	3.01	2.75	1.86	0.835	1.073	0.223	0.788	0.104
6	0.01337	0.574	0.044	2 1/2"		10.08	51.9	6.33	15.8	3.61	3.84	2.23	1.17	1.29	0.309	0.946	0.145
8	0.01782	0.765	0.073			13.44	91.1	8.45	27.7	4.81	6.60	2.97	1.99	1.72	0.518	1.26	0.241
10	0.02228	0.956	0.108	0.670	0.046			10.56	42.4	6.02	9.99	3.71	2.99	2.15	0.774	1.58	0.361
15	0.03342	1.43	0.224	1.01	0.094	3"				9.03	21.6	5.57	6.36	3.22	1.63	2.37	0.755
20	0.04456	1.91	0.375	1.34	0.158	0.868	0.056	3 1/2"		12.03	37.8	7.43	10.9	4.29	2.78	3.16	1.28
25	0.05570	2.39	0.561	1.68	0.234	0.090	0.083	0.812	0.041			9.28	16.7	5.37	4.22	3.94	1.93
30	0.06684	2.87	0.786	2.01	0.327	1.30	0.114	0.974	0.056	4"		11.14	23.8	6.44	5.92	4.73	2.72
35	0.07798	3.35	1.05	2.35	0.436	1.52	0.151	1.14	0.074	0.882	0.041	12.99	32.2	7.51	7.90	5.52	3.64
40	0.08912	3.83	1.35	2.68	0.556	1.74	0.192	1.30	0.095	1.01	0.052	14.85	41.5	8.59	10.24	6.30	4.65
45	0.1003	4.30	1.67	3.02	0.668	1.95	0.239	1.46	0.117	1.13	0.064			9.67	12.80	7.09	5.85
50	0.1114	4.78	2.03	3.35	0.839	2.17	0.288	1.62	0.142	1.26	0.076			10.74	15.66	7.88	7.15
60	0.1337	5.74	2.87	4.02	1.18	2.60	0.406	1.95	0.204	1.51	0.107	5"		12.89	22.2	9.47	10.21
70	0.1560	6.70	3.84	4.69	1.59	3.04	0.540	2.27	0.261	1.76	0.143	1.12	0.047			11.05	13.71
80	0.1782	7.65	4.97	5.36	2.03	3.47	0.687	2.60	0.334	2.02	0.180	1.28	0.060			12.62	17.59
90	0.2005	8.60	6.20	6.03	2.53	3.91	0.861	2.92	0.416	2.27	0.224	1.44	0.074	6"		14.20	22.0
100	0.2228	9.56	7.59	6.70	3.09	4.34	1.05	3.25	0.509	2.52	0.272	1.60	0.090	1.11	0.036	15.78	26.9
125	0.2785	11.97	11.76	8.38	4.71	5.43	1.61	4.06	0.769	3.15	0.415	2.01	0.135	1.39	0.055	19.72	41.4
150	0.3342	14.36	16.70	10.05	6.69	6.51	2.24	4.87	1.08	3.78	0.580	2.41	0.190	1.67	0.077		
175	0.3899	16.75	22.3	11.73	8.97	7.60	3.00	5.68	1.44	4.41	0.774	2.81	0.253	1.94	0.102	8"	
200	0.4456	19.14	28.8	13.42	11.68	8.68	3.87	6.49	1.85	5.04	0.985	3.21	0.323	2.22	0.130		
225	0.5013	-	-	15.09	14.63	9.77	4.83	7.30	2.32	5.67	1.23	3.61	0.401	2.50	0.162	1.44	0.043
250	0.5570	-	-	-	-	10.85	5.93	8.12	2.84	6.30	1.46	4.01	0.495	2.78	0.195	1.60	0.051
275	0.6127	-	-	-	-	11.94	7.14	8.93	3.40	6.93	1.79	4.41	0.583	3.05	0.234	1.76	0.061
300	0.6684	-	-	-	-	13.00	8.36	9.74	4.02	7.56	2.11	4.81	0.683	3.33	0.275	1.92	0.072
350	0.7798			-	-	-	-	11.36	5.41	8.82	2.84	5.62	0.919	3.89	0.367	2.24	0.095
400	0.8912					-	-	12.98	7.03	10.08	3.68	6.42	1.19	4.44	0.471	2.56	0.121
450	1.0030	10"				-	-	14.61	8.80	11.34	4.60	7.22	1.48	5.00	0.590	2.89	0.151
500	1.114	2.03	0.059	12"		-	-	-	-	12.60	5.65	8.02	1.81	5.55	0.720	3.21	0.182
600	1.337	2.44	0.083					-	-	15.12	8.04	9.63	2.55	6.66	1.02	3.85	0.258
700	1.560	2.85	0.112	2.01	0.047	14"		-	-	-	-	11.23	3.43	7.78	1.35	4.49	0.343
800	1.782	3.25	0.143	2.29	0.061					-	-	12.83	4.43	8.88	1.75	5.13	0.443
900	2.005	3.66	0.179	2.58	0.075	2.13	0.047	16"		-	-	14.44	5.58	9.99	2.18	5.77	0.554
1000	2.228	4.07	0.218	2.87	0.091	2.37	0.057					16.04	6.84	11.10	2.68	6.41	0.675
1200	2.674	4.88	0.306	3.44	0.128	2.85	0.080	2.18	0.042			-	-	13.33	3.81	7.70	0.948
1400	3.119	5.70	0.409	4.01	0.171	3.32	0.107	2.54	0.055	18"		-	-	15.55	5.13	8.98	1.28
1600	3.565	6.51	0.527	4.59	0.219	3.79	0.138	2.90	0.071			-	-	17.77	6.61	10.26	1.65
1800	4.010	7.32	0.663	5.16	0.276	4.27	0.172	3.27	0.088	2.58	0.050			19.99	8.37	11.54	2.08
2000	4.456	8.14	0.808	5.73	0.339	4.74	0.209	3.63	0.107	2.87	0.060			22.21	10.3	12.82	2.55



Valve & Fitting Losses Expressed in Equivalent Feet of Pipe

Pipe Fitting or Valve	Nominal Pipe or Tube Size (inches) 3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	5	6	8
1 90° Standard Elbow	1.4	1.6	2.0	2.6	3.3	4.0	5.0	6.0	7.5	9.0	10	13	16	20
2 45° Standard Elbow	0.7	0.8	0.9	1.3	1.7	2.1	2.6	3.2	4.0	4.7	5.2	6.5	7.9	10
3 Flow-Through Branch Tee	2.7	3.0	4.0	5.0	7.0	8.0	10	12	15	18	21	25	30	40
4 Straight Through Flow Tee - No Reduction	0.9	1.0	1.4	1.7	2.3	2.6	3.3	4.1	5.0	5.9	6.7	8.2	10	13
5 Straight Through Flow Tee- Reduced 1/4	1.2	1.4	1.9	2.3	3.1	3.7	4.7	5.6	7.0	8.0	9.0	12	14	18
6 Straight Through Flow Tee - Reduced 1/8	1.4	1.6	2.0	2.6	3.3	4.0	5.0	6.0	7.5	9.0	10	13	16	20
7 Globe Valve - Fully opened	17	18	22	29	38	43	55	69	84	100	120	140	170	220
8 Gate Valve - Fully opened	0.6	0.7	0.9	1.0	1.5	1.8	2.3	2.8	3.2	4.0	4.5	6.0	7.0	9.0

Notes

FLOW OF AIR THROUGH SCHEDULE 40 STEEL PIPE

Free Air ft^3/min. at 60°F & 14.7 psia	Compressed Air ft^3/min. at 60°F at 100 psig	Pressure Drop per 100’ of Schedule 40 Pipe For Air For 60°F and 100 Pounds Per Square Inch (PSI)									
		1/8"	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"
1	0.128	0.361	0.083	0.018							
2	0.256	1.31	0.285	0.064	0.020						
3	0.384	3.06	0.605	0.133	0.042						
4	0.513	4.83	1.04	0.226	0.071						
5	0.641	7.45	1.58	0.343	0.106	0.027					
6	0.769	10.6	2.23	0.408	0.148	0.037					
8	1.025	18.6	3.89	0.848	0.255	0.062	0.019				
10	1.282	28.7	5.96	1.26	0.356	0.094	0.029				
15	1.922		13.0	2.73	0.834	0.201	0.062				
20	2.563		22.8	4.76	1.43	0.345	0.102	0.026			
25	3.204		35.6	7.34	2.21	0.526	0.156	0.039	0.019		
30	3.845			10.5	3.15	0.748	0.219	0.055	0.026		
35	4.486			14.2	4.24	1.00	0.293	0.073	0.035		
40	5.126			18.4	5.49	1.30	0.379	0.095	0.044		
45	5.767			23.1	6.90	1.62	0.474	0.116	0.055		
50	6.408			28.5	8.49	1.99	0.578	0.149	0.067	0.019	
60	7.690			40.7	12.2	2.85	0.819	0.200	0.094	0.027	
70	8.971				16.5	3.83	1.10	0.270	0.126	0.036	
80	10.25				21.4	4.96	1.43	0.350	0.162	0.046	0.019
90	11.53				27.0	6.25	1.80	0.437	0.203	0.058	0.023

Pipe Dimensions & Weights

Nominal Pipe Size NPS [DN]	OD in [mm]	Schedule			Wall Thickness in	ID in	Weight lb/ft
1/8	**0.405**		10	10S	0.049	0.307	0.19
[6]	[10.3]	STD	40	40S	0.068	0.269	0.25
		XS	80	80S	0.095	0.215	0.32
1/4	**0.540**		10	10S	0.065	0.410	0.33
[8]	[13.7]	STD	40	40S	0.088	0.364	0.43
		XS	80	80S	0.119	0.302	0.54
3/8	**0.675**		10	10S	0.065	0.545	0.42
	[17.1]	STD	40	40S	0.091	0.493	0.57
[10]		XS	80	80S	0.126	0.423	0.74
			5	5S	0.065	0.710	0.54
1/2	**0.840**		10	10S	0.083	0.674	0.67
		STD	40	40S	0.109	0.622	0.85
[15]	[21.3]	XS	80	80S	0.147	0.546	1.09
			160		0.188	0.464	1.31
		XX			0.294	0.252	1.71
			5	5S	0.065	0.920	0.68
3/4	**1.050**		10	10S	0.083	0.884	0.86
		STD	40	40S	0.113	0.824	1.13
[20]	[26.7]	XS	80	80S	0.154	0.742	1.47
			160		0.219	0.612	1.94
		XX			0.308	0.434	2.44
			5	5S	0.065	1.185	0.87
1	**1.315**		10	10S	0.109	1.097	1.40
		STD	40	40S	0.133	1.049	1.68
[25]	[33.4]	XS	80	80S	0.179	0.957	2.17
			160		0.250	0.815	2.84
		XX			0.358	0.599	3.66
			5	5S	0.065	1.530	1.11
1-1/4	**1.660**		10	10S	0.109	1.442	1.81
		STD	40	40S	0.140	1.380	2.27
[32]	[42.2]	XS	80	80S	0.191	1.278	3.00
			160		0.250	1.160	3.77
		XX			0.382	0.896	5.21
			5	5S	0.065	1.770	1.27
1-1/2	**1.900**		10	10S	0.109	1.682	2.09
		STD	40	40S	0.145	1.610	2.72
[40]	[48.3]	XS	80	80S	0.200	1.500	3.63
			160		0.281	1.338	4.86
		XX			0.400	1.100	6.41
			5	5S	0.065	2.245	1.60
2	**2.375**		10	10S	0.109	2.157	2.64
		STD	40	40S	0.154	2.067	3.65
[50]	[60.3]	XS	80	80S	0.218	1.939	5.02
			160		0.344	1.687	7.46
		XX			0.436	1.503	9.03
			5	5S	0.083	3.334	3.03
3	**3.500**		10	10S	0.120	3.260	4.33
		STD	40	40S	0.216	3.068	7.58
[80]	[88.9]	XS	80	80S	0.300	2.900	10.25
			160		0.438	2.624	14.32
		XX			0.600	2.300	18.58
			5	5S	0.083	3.834	3.47
3-1/2	**4.000**		10	10S	0.120	3.760	4.97
		STD	40	40S	0.226	3.548	9.11
[90]	[101.6]	XS	80	80S	0.318	3.364	12.51
		XX			0.636	2.728	22.85

Nominal Pipe Size NPS [DN]	OD in [mm]	Schedule			Wall Thickness in	ID in	Weight lb/ft
			5	5S	0.083	4.334	3.92
			10	10S	0.120	4.260	5.61
4	**4.500**	STD	40	40S	0.237	4.026	10.79
		XS	80	80S	0.337	3.826	14.98
[100]	[114.3]		120		0.438	3.624	19.00
			160		0.531	3.438	22.51
		XX			0.674	3.152	27.54
			5	5S	0.109	6.407	7.59
			10	10S	0.134	6.357	9.29
6	**6.625**	STD	40	40S	0.280	6.065	18.97
		XS	80	80S	0.432	5.761	28.57
[150]	[168.3]		120		0.562	5.501	36.39
			160		0.719	5.187	45.35
		XX			0.864	4.897	53.16
				5S	0.109	8.407	9.91
			10	10S	0.148	8.329	13.40
			20		0.250	8.125	22.36
			30		0.277	8.071	24.70
		STD	40	40S	0.322	7.981	28.55
8	**8.625**		60		0.406	7.813	35.64
[200]	[219.1]	XS	80	80S	0.500	7.625	43.39
			100		0.594	7.437	50.95
			120		0.719	7.187	60.71
			140		0.812	7.001	67.76
		XX			0.875	6.875	72.43
			160		0.906	6.813	74.69
				5S	0.134	10.482	15.19
				10S	0.165	10.420	18.65
			20		0.250	10.250	28.04
			30		0.307	10.136	34.24
10	**10.750**	STD	40	40S	0.365	10.020	40.48
		XS	60	80S	0.500	9.750	54.74
[250]	[273.1]		80		0.594	9.562	64.43
			100		0.719	9.312	77.03
			120		0.844	9.062	89.29
			140		1.000	8.750	104.13
			160		1.125	8.500	115.65
				5S	0.156	12.438	20.98
				10S	0.180	12.390	24.17
			20		0.250	12.250	33.38
			30		0.330	12.090	43.77
		STD		40S	0.375	12.000	49.56
12	**12.750**		40		0.406	11.938	53.53
		XS		80S	0.500	11.750	65.42
[300]	[323.9]		60		0.562	11.626	73.16
			80		0.688	11.374	88.63
			100		0.844	11.062	107.32
			120		1.000	10.750	125.49
			140		1.125	10.500	139.68
			160		1.312	10.126	160.27

Engineering. Engineering. Engineering. Engineering. Engineering.

BETE Fog Nozzle, Inc. Application Intake Sheet

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Name: ______________________ **Company:** ______________________

Telephone: ______________________ **Company Address:** ______________________

FAX: __________________ **email:** __________________ **BETE Cust. #** ________

Sketch a simple representation of the application below:

• What are you trying to accomplish with the spray?

• What is the available pressure?

• What is the desired material of construction?

• What is the flow rate?

• What is the piping material?

• What is the desired flow rate?

• What are the size and connection types desired?

• What liquid is being sprayed?

• What is the distance from the nozzle to the target?

• What is the desired spray angle or coverage?

• What are the environmental conditions surrounding the nozzle?