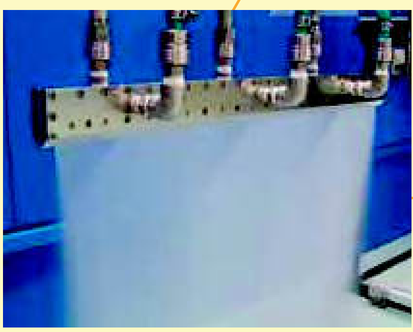
IKEUCHI

Catalog on Pneumatic Spray Nozzles



"The Fog Engineers"

H. IKEUCHI & CO., LTD.

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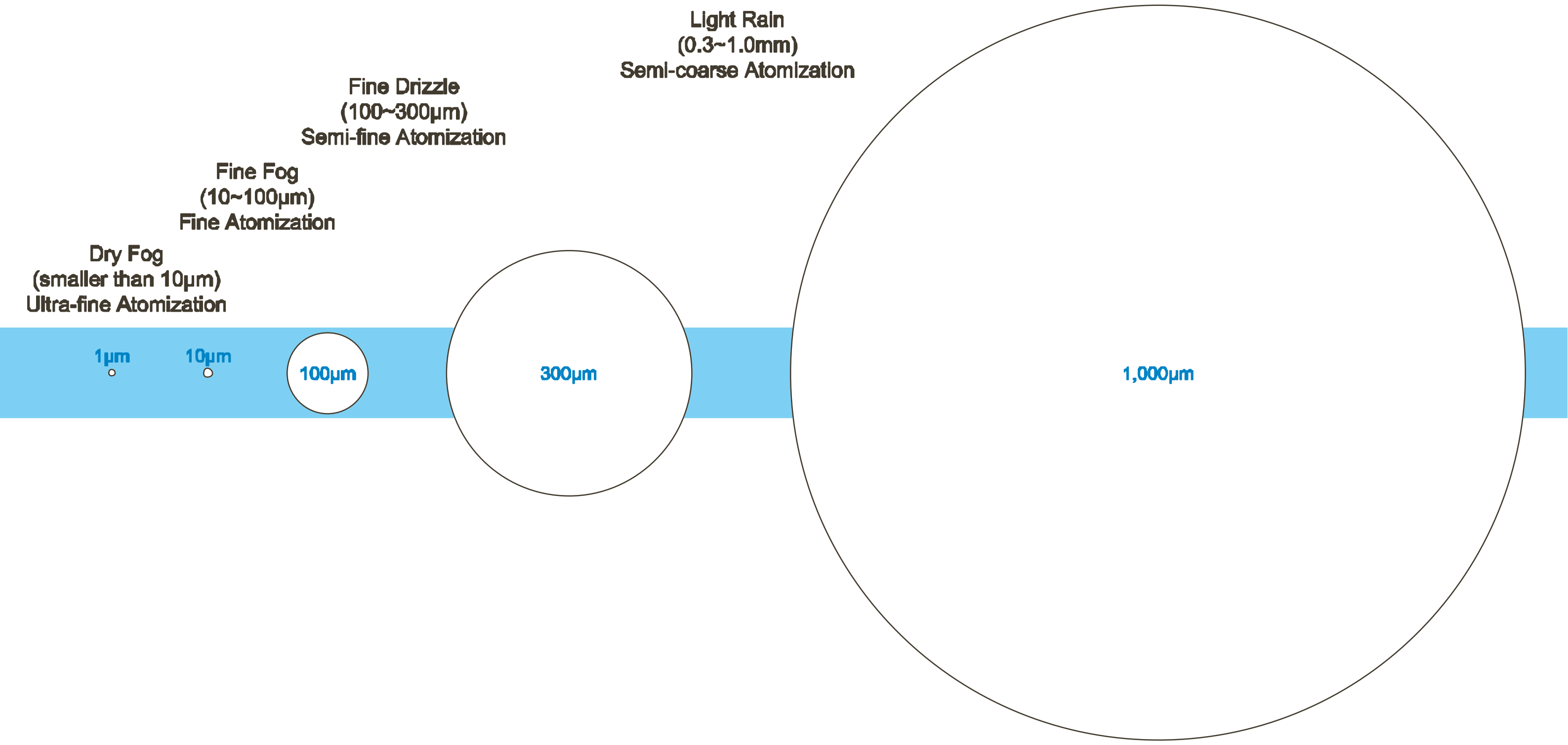
Classification of Spray Droplet Size

There are may opinions on the classification of spray droplet sizes but IKEUCHI, "The Fog Engineers", have classified them as below.



What are Pneumatic Spray Nozzles? (before selection)

The pneumatic spray nozzle utilizes a high-velocity flow of compressed air and has the following features as compared with hydraulic spray nozzles.

【Features】

1. Excellent atomizing performance

The minimum average droplet size produced by hydraulic spray nozzles is around 50μm(*1) but pneumatic spray nozzles can generate average droplet sizes smaller than 10μm(*1).

2. Large turn-down ratio

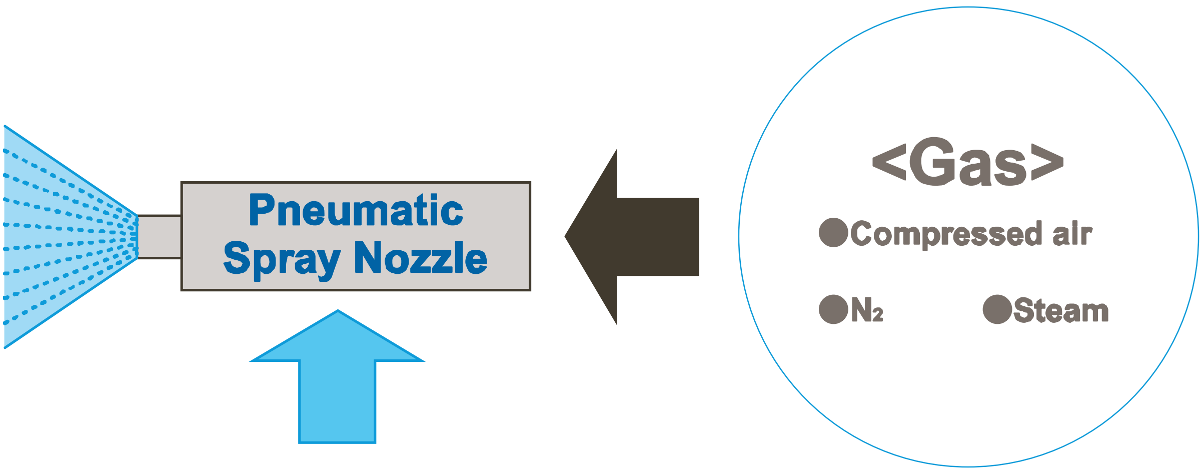
Pneumatic spray nozzles have large turn-down ratios of spray flow-rate(*2) with little variation in droplet size and spray distribution, which makes them ideal for spray flow adjustable nozzles.

3. Large free passage diameter

Pneumatic spray nozzles have larger free passage diameters as compared with hydraulic nozzles, which is effective for reducing clogging problems.

*1) Measured by immersion sampling method (See page 6 for the droplet measuring method)
*2) Spray flow rate is expressed as spray capacity in this catalog. Please see page 8 for the turn-down ratio.

Various types of pneumatic spray nozzles are available.
Please select a suitable nozzle for each application.

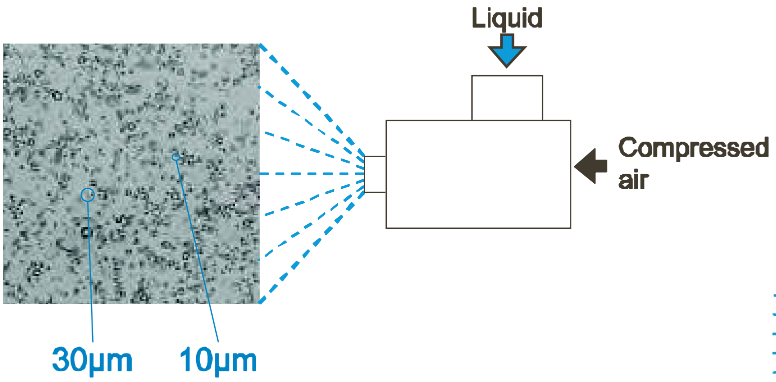


Usually, pneumatic spray nozzles are driven by compressed air but inert gas (N_2, etc.) or steam are also used.

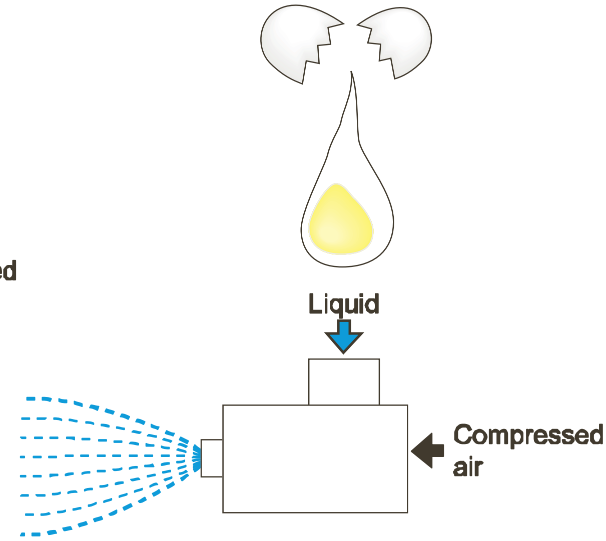
Note: For use of steam, please contact us.
The figures shown in this catalog are based on compressed air and tap water at room temperature.

【Applications】

Where fine atomization is required…

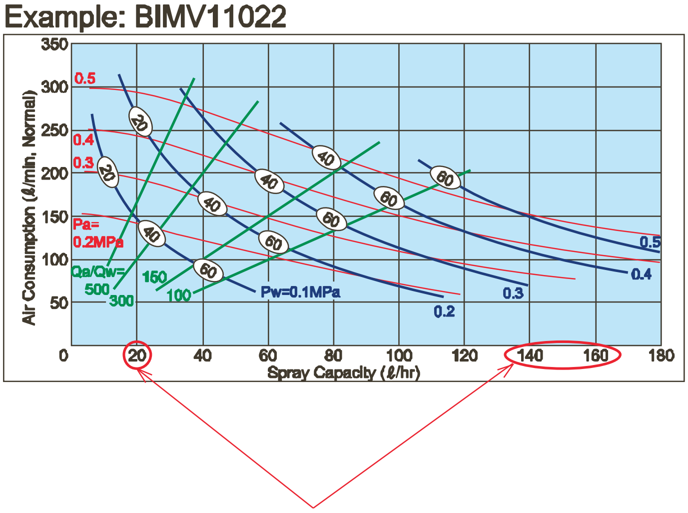


Where viscous liquid is sprayed…



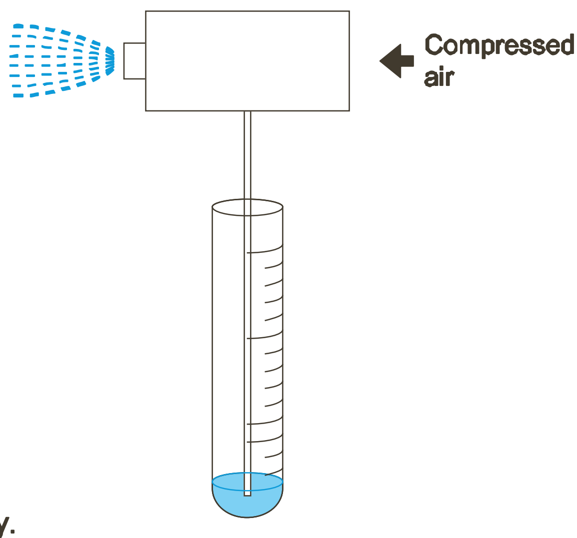
Where a large turn-down ratio is required…

Example: BIMV11022



One spray nozzle can cover a wide range of spray capacity.

Where extremely small spray capacity is required…



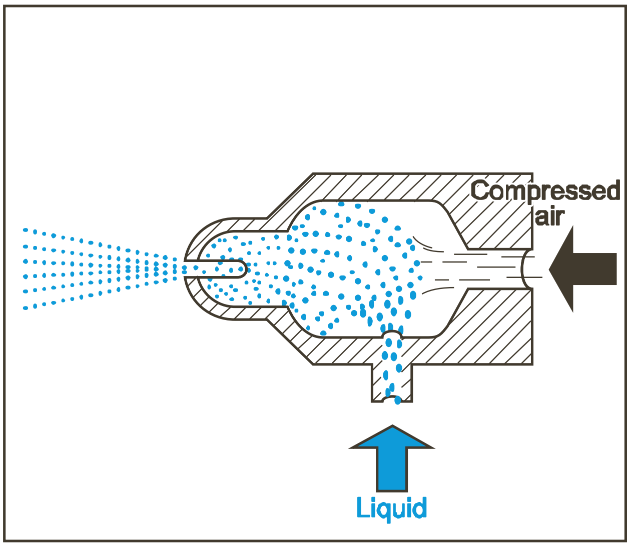
Technical Information on Pneumatic Spray Nozzles

1. Air-liquid mixing systems

Three air-liquid mixing systems are available for atomizing liquid.

Internal mixing type

Compressed air and liquid are mixed inside the nozzle.
Generally, this type is excellent for atomizing liquid.



This internal mixing type is further classified into three types.

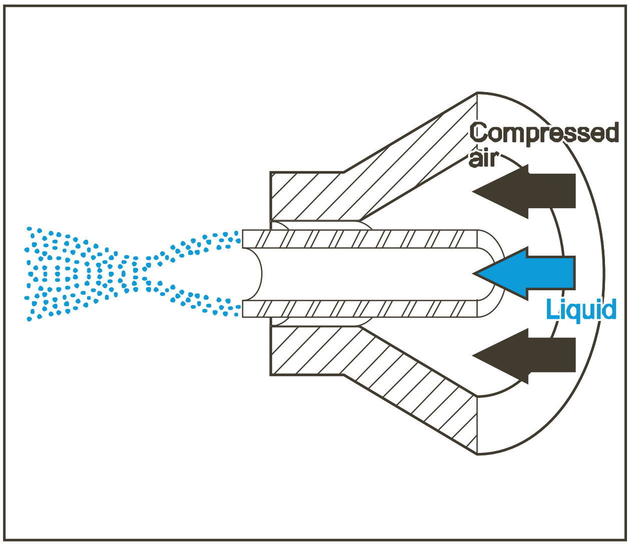
1. Inner air type…… Compressed air flows in the center of the nozzle, while liquid flows along its circumference. This type provides an important benefit with a larger free passage diameter which minimizes clogging.

2. Outer air type…… Liquid flows in the center of the nozzle, while compressed air flows along its circumference. This type of nozzle is selected for wide range of applications. Larger orifice size can be designed on demand while the spray droplets become a little coarser.

3. Pre-mix type…… Even at a low air-water ratio, the increased velocity of the droplets results in a strong impact force. Furthermore, the turn-down ratio is larger and this type is suitable for cooling objects in high temperature range.

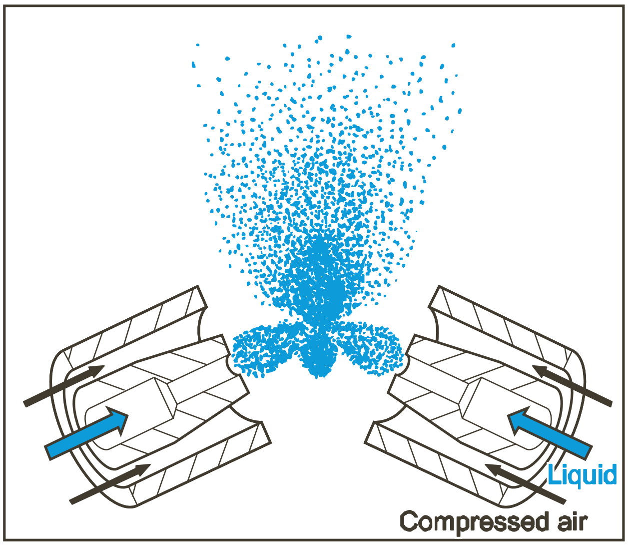
External mixing type

Compressed air and liquid are mixed outside the nozzle. Hence, this type clogs the least. This is also classified into inner air type and outer air type.



Impinging type

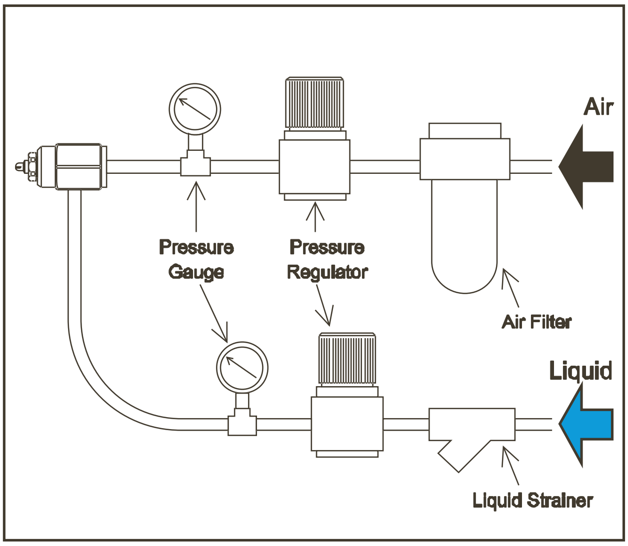
Air-stream entraining fine fog jets out from the nozzle and impinges against another air-stream of the same nature for shattering the fog into even finer, more-uniform droplets. This is an original method of IKEUCHI, "The Fog Engineers."



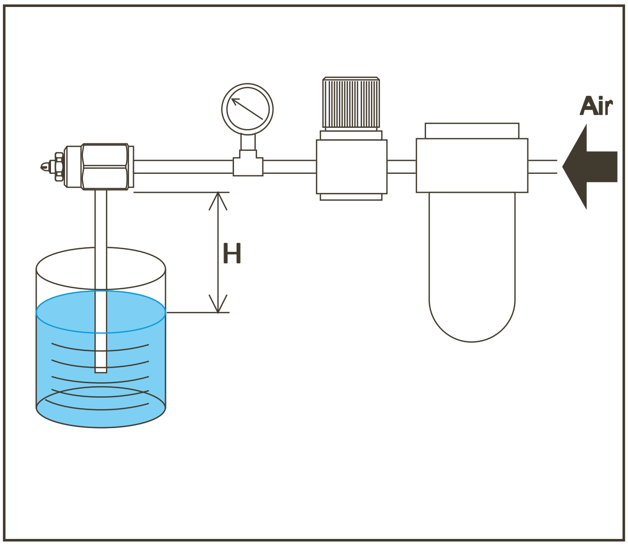
2. Liquid feeding system

Two liquid feeding systems are available.
One is the liquid pressure system and the other is the liquid siphon system.

Liquid pressure system

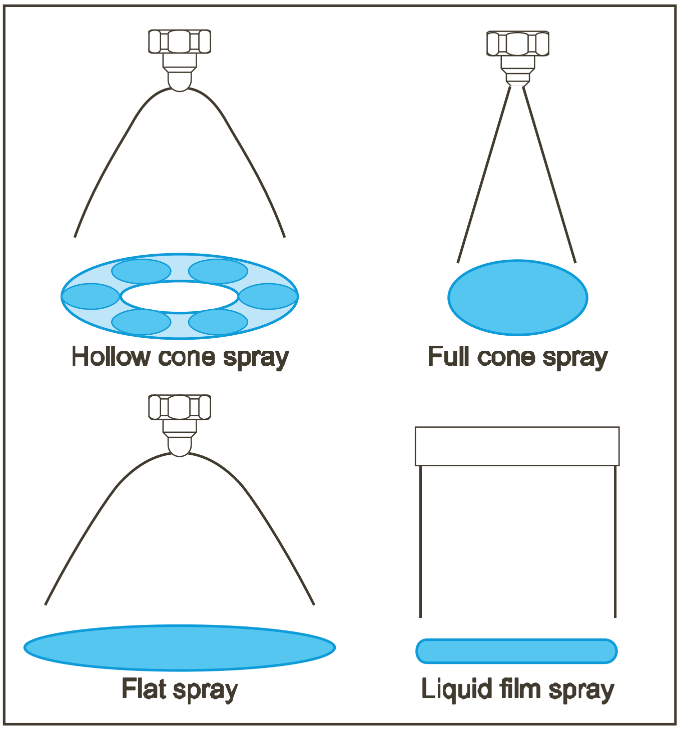


Liquid siphon system



Spray capacity differs depending on liquid siphon height (H).

3. Spray pattern



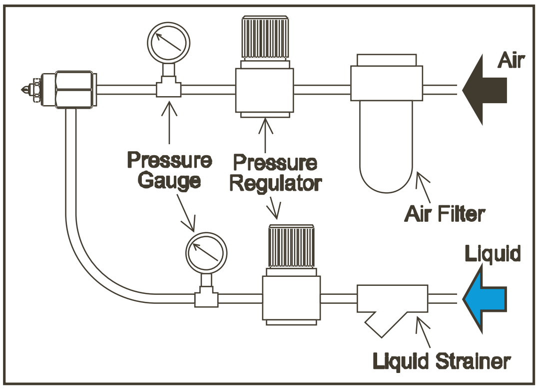
Spray pattern means the cross sectional shape of spray.
As illustrated, spray patterns are available in cone spray (hollow cone spray and full cone spray), flat spray, and liquid film spray.
The best spray pattern among them can be selected for each application.

Hollow cone sprays and full cone sprays are suitable for humidification, cooling gases, chemical reactions and moisture control, etc., while flat sprays and liquid film spray are suitable for cooling, coating, etc.

The spray patterns of pneumatic spray nozzles deform significantly as the distance from the nozzle becomes greater.

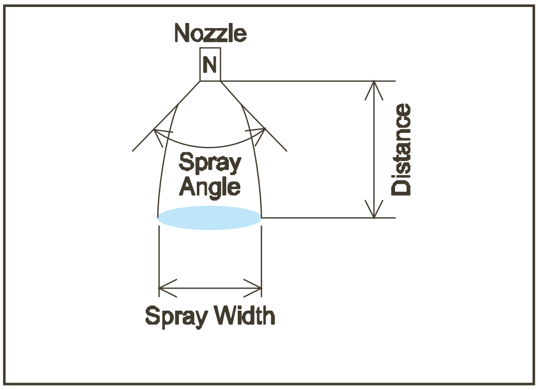
Technical Information on Pneumatic Spray Nozzles

4. Spray pressure



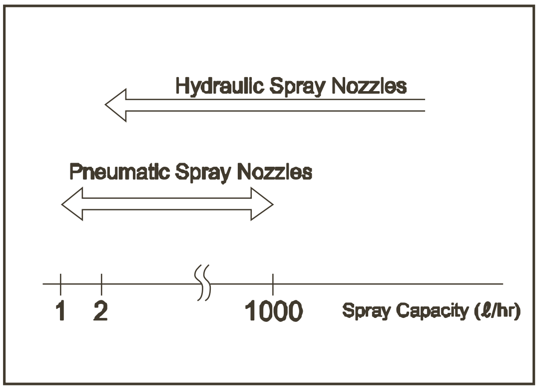
For each series of pneumatic spray nozzles, the most commonly used pressures or pressures at which the characteristics can be achieved are defined as the standard pressures.
The figures in this catalog are based on compressed air and tap water at room temperature and the pressures are measured at the immediate upstream of each nozzle.

5. Spray angle



The spray angle is measured at the top of the spray made by straight lines extending along the outer edges of the spray.
Pneumatic spray nozzle's flow velocity is so fast that the specified spray angle is maintained only at the top of spray.
For nozzle alignment, please refer to the spray width data indicated in each table.

6. Spray capacity

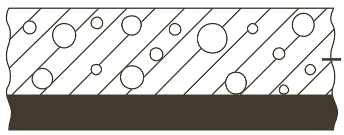
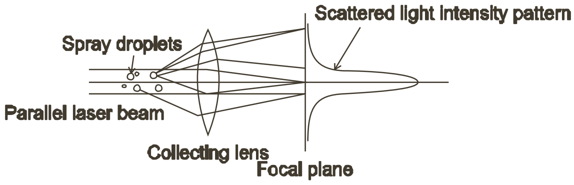
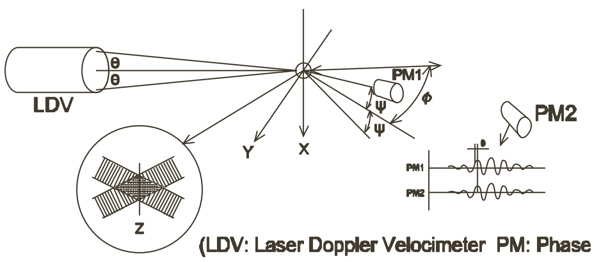


The spray capacity is the water volume flow rate sprayed from the nozzle. One of the features of pneumatic spray nozzle is to spray at extremely small capacity such as 17cc/min. or 1ℓ/hr.
Spray capacities shown in this catalog are based on tap water at room temperature.
(The air consumption is expressed as the normal volume at atmospheric pressure.)

Standard pressure and spray capacity inspection standard (at each standard pressure) are set for each pneumatic spray nozzle series.
Only the nozzles that pass the inspection will be shipped.

7. Spray droplet size

1) Principles and features of each droplet measuring method

Measuring method	Principle and features	Proper range of droplet size measurement
Immersion sampling method	Droplets are collected on a glass plate coated with silicon oil and are immediately photographed at high magnification for subsequent scanning. As the collected droplets remain suspended in the silicon oil, they are measured as perfect spheres. However, ultra-fine droplets are incapable of breaking the surface tension of the oil and will evaporate without settling. Thus, the average droplet size determined by this method is larger than the actual value. 	10~5,000μm
Laser analyzer: Fraunhofer diffraction method	A laser beam scatters at the surface of droplets in the laser beam path and the diffraction pattern due to interference of scattered light is focused behind the droplets. This method can simultaneously measure all droplets on the laser beam path but if the concentration of droplets is too high, it would result in a phenomenon (multi-scatter) such that a once-scattered laser beam is re-scattered due to another droplet, which could then cause the measured droplet size to be smaller than the actual droplet size. 	1~1,000μm
Laser analyzer: Laser Doppler method	This method forms an interference fringe by crossing two laser beams. In detail, this method detects scattered light, which results from droplets having passed through this interference fringe, by two or more receivers located at a certain distance from the spray and determines droplet size from the phase difference at that time. This method is not as affected by droplet concentration because it measures droplets one by one and, as one more advantage, it can measure droplet velocity simultaneously. However, the measurement is made only at one point.  (LDV: Laser Doppler Velocimeter PM: Phase monitor)	0.5~2,500μm

Technical Information on Pneumatic Spray Nozzles

2) Mean droplet diameter

■Example of calculation of Sauter mean droplet diameter

Range(μm)	Mean value(μm)	Q'ty(n)	nd²	nd³
0-100	50	1664	4160000	208000000
100-200	150	2072	46620000	6993000000
200-300	250	444	27750000	6937500000
300-400	350	161	19722500	6902875000
400-500	450	73	14782500	6652125000
500-600	550	35	10587500	5823125000
600-700	650	17	7182500	4668625000
700-800	750	4	2250000	1687500000
	Total	4470	133055000	3.987275×10^{10}

$$\bar{d}_{32}=\frac{\Sigma nd^3}{\Sigma nd^2}=300\mu m$$

Mean droplet diameter is one of the important factors in selecting nozzles and designing nozzle-related equipment. Commonly used definitions include the following three.

- ●Sauter Mean Droplet Diameter ($\bar{d}_{32}$)··········· $\Sigma nd^3/\Sigma nd^2$
- ●Volume Mean Droplet Diameter ($\bar{d}v$)··········· $(\Sigma nd^3/\Sigma n)^{1/3}$
- ●Mass Median Droplet Diameter ($D_{V.5}$)··········· $\int_0^{D_{V.5}} dv/v = \int_{D_{V.5}}^{\infty} dv/v = 50\%$

It is often used in chemical processes such as cooling, evaporation, combustion and drying, where efficiency is determined by the ratio of volume to surface area, i.e. specific surface. Because a small portion of large droplets is more influential over the rate of reaction than a large portion of small droplets, it is advisable to use Sauter Mean Droplet Diameter as the representative droplet size. Sauter Mean Diameter is used in this catalog.

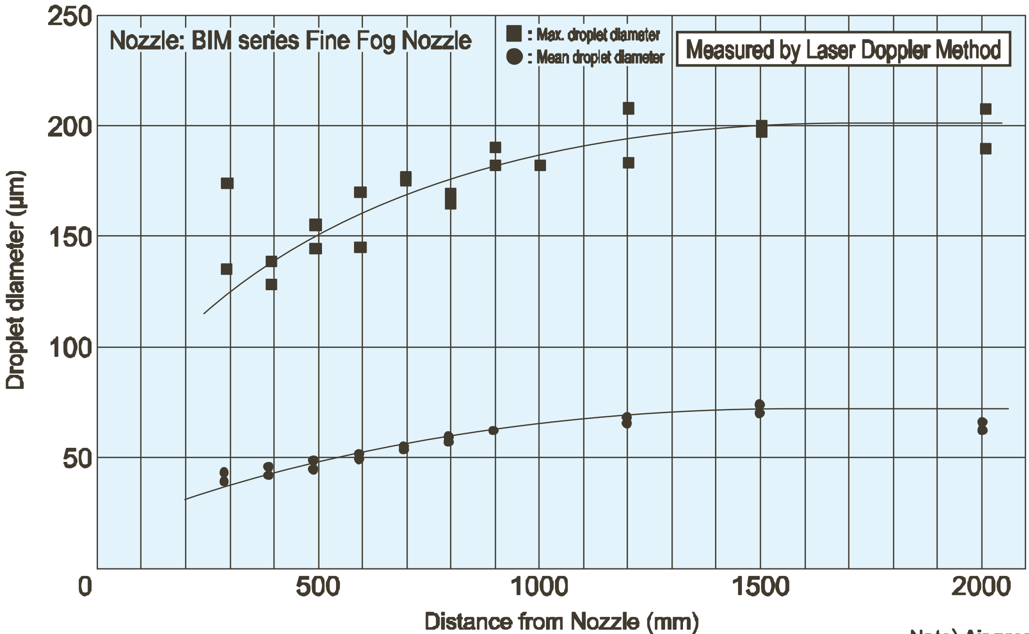
3) Correlation of spray droplet diameter

Measured results differ depending on each measuring method. Assuming the droplet diameter measured by the immersion sampling method as 1, the correlation of Sauter mean droplet diameters among three measuring methods is shown right.

Nozzle type \ Measuring method		Immersion Sampling Method	Fraunhofer Diffraction Method	Laser Doppler Method
Hydraulic spray nozzles	Flat spray, Full cone spray	1	0.45	0.7~0.9
	Hollow cone spray	1	0.45	0.7~0.9
Pneumatic spray nozzles	Fine & semi-fine atomization	1	0.45	0.7~0.9
	Ultra-fine atomization	1	0.45	0.7~0.9

4) Evaluation of droplet diameter

Good care must be exercised in evaluating droplet diameter because droplet diameters differ depending on each measuring method as described above. In comparing spray droplet diameters of several different spray nozzles, needless to say, the measuring method applied must be uniform and, when the laser method is applied, measurement distance, droplet concentration, etc. must also be as consistent as possible.
Too high a concentration would result in multiple scattering in the Fraunhofer laser diffraction and Laser Doppler methods, which would then prevent correct evaluation of droplet diameter. Therefore, it is desirable to avoid measuring at proximity with the nozzle and to measure at a standardized distance from the nozzle.

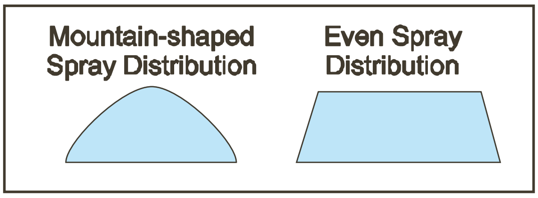


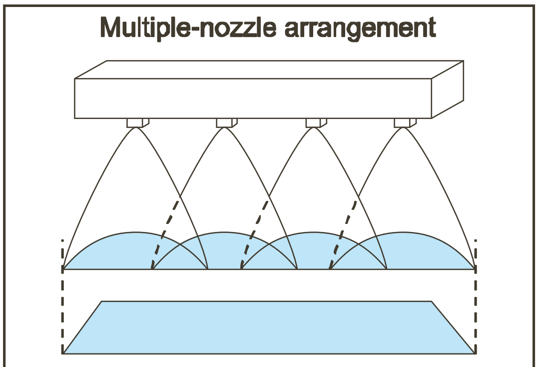
Droplet diameters at various distances from the nozzle

Note) Air pressure: 0.49MPa
Liquid pressure: 0.46MPa

8. Spray distribution

The spray distribution means the distribution of spray capacity in the spray width direction.
A mountain-shaped distribution is useful in producing uniform spray distribution across the entire spray width by overlapping patterns in multiple-nozzle arrangements, while even spray distribution is suitable for applications that require uniform spray distribution by one nozzle. The spray distribution depends on operational conditions such as spray height, pressure and other conditions.

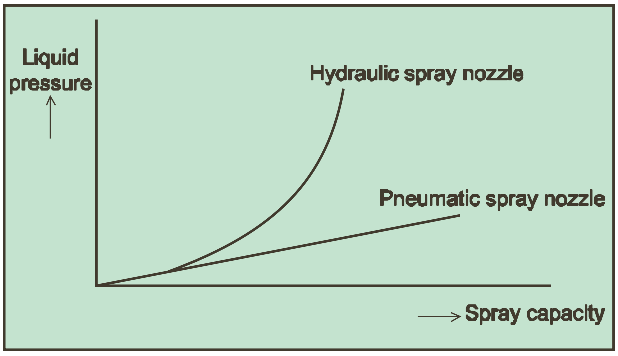




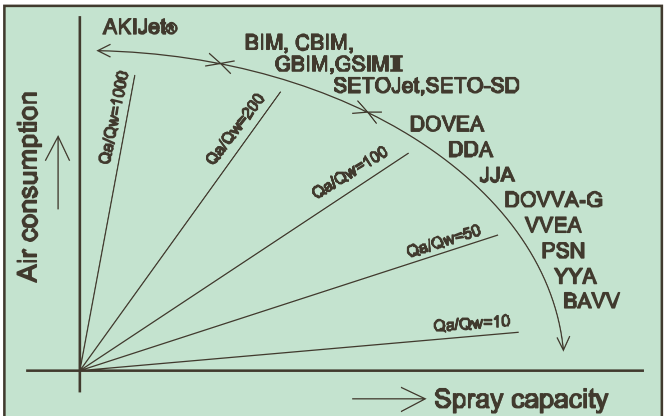
Mountain-shaped flat spray nozzles installed at proper spacing produce uniform distribution across the entire spray area in multiple-nozzle arrangements.

9. Turn-down ratio

The turn-down ratio means the ratio between the adjustable minimum spray capacity and the maximum spray capacity. The spray capacity of hydraulic spray nozzles is proportional to square root of the pressure and the variation of spray capacity greatly depends on the power of pump, so the turn-down ratio is small.
On the other hand, pneumatic spray nozzles enable users to obtain large turn-down ratios by adjusting both air and liquid pressures. Hence, pneumatic spray nozzles are the most suitable for cooling combustion fumes or applications requiring the nozzles producing small droplets and having large turn-down ratios.



10. Air-water ratio



Note: Qa/Qw·······Air-water ratio (volume basis)

Air-water ratio means the rate of air consumption divided by spray capacity. This is expressed as either a volume ratio or weight ratio. If the nozzles used are the same, the spray droplet size becomes smaller as the air-water ratio becomes higher.

The air-water ratio in this catalog is based on volume ratio, unless specifically stated.

Spray Nozzle Materials

The standard and optional materials available for nozzles are shown in the material section of each nozzle series, using the material codes listed below.
As "The Fog Engineers", we, IKEUCHI, have been developing nozzles in a variety of materials to meet the desires and applications of our customers. We were the first to develop ceramic orifice-inserted spray nozzles and succeed in marketing them throughout the world.

Metals

Material code	Material
S303	Stainless steel 303
S304	Stainless steel 304
S304L	Stainless steel 304L
S316	Stainless steel 316
S316L	Stainless steel 316L
S321	Stainless steel 321

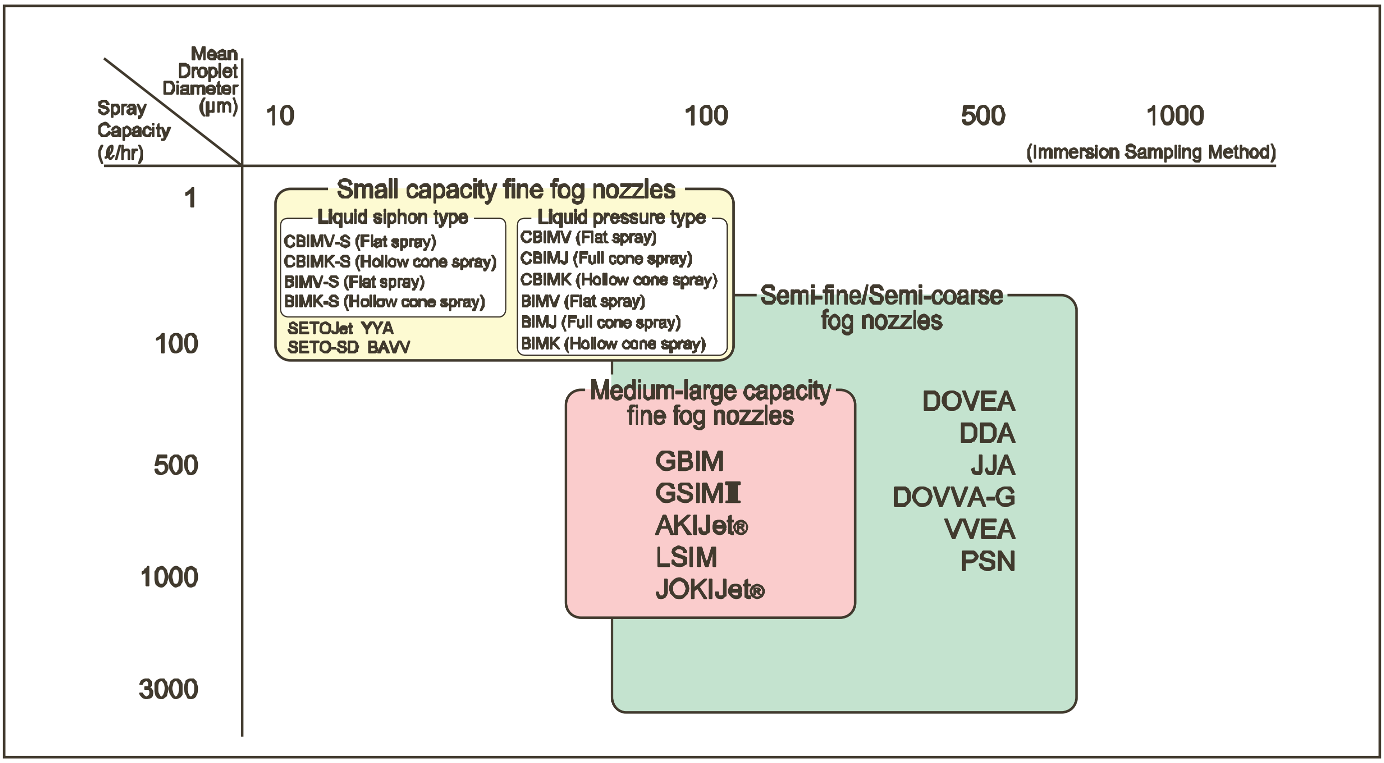
Plastics

Material code	Material
PP	Polypropylene
PE	Polyethylene
PTFE	Polytetrafluoroethylene

Rubbers

Material code	Material
FKM (FPM)	Tetrafluoroethylene-propylene rubber
NBR	Nitrile rubber

How to Select Pneumatic Spray Nozzles



Driven by	Nozzle type	Spray pattern	Liquid feeding system	Series	Air-liquid mixing system	Spray capacity	units	Spray angle (°)	Air consumption (ℓ/min, Normal)	Page
Compressor	Small capacity Fine fog nozzle	Flat spray	Liquid pressure	BIMV, CBIMV	Internal mixing Inner air type	1.0 ~ 107	ℓ/hr	110~45	15 ~ 250	13, 31
				YYA		2.2 ~ 10.0		80	27 ~ 54	72
			Liquid siphon	BIMV-S, CBIMV-S		0.7 ~ 4.5		80	15 ~ 94	15, 33
		Hollow cone spray	Liquid pressure	BIMK, CBIMK		2.0 ~ 107		60	27 ~ 250	17, 32
			Liquid siphon	BIMK-S, CBIMK-S		1.5 ~ 5		60	27 ~ 94	19, 33
		Full cone spray	Liquid pressure	BIMJ, CBIMJ		2.0 ~ 107		20	27 ~ 250	21, 32
	Medium-large capacity Fine fog nozzle	Full cone spray	Liquid pressure	GBIM	Internal mixing Outer air type	70 ~1560		20~60	340 ~ 5900	37
			Liquid pressure	GSIMⅡ						41
			Liquid pressure & Liquid siphon	AKIJet®	Impinging type			-		74
			Liquid pressure	AKIJet®-S						76
	Semi-fine/ Semi-coarse fog nozzle	Flat spray	Liquid pressure	VVEA	Internal mixing Pre-mix type	0.29 ~ 4.5	ℓ/min	60,80	14 ~ 128	61
			Liquid pressure	DOVEA		0.42 ~ 40		110~55	30 ~ 620	47
			Liquid pressure	DDA		0.5 ~ 57.3		125~25	170 ~ 610	52
			Liquid pressure	DOVVA-G		1.0 ~ 25		55,70	100 ~ 1700	58
		Full cone spray	Liquid pressure	JJA		0.9 ~ 23.9		–	50 ~ 690	55
		Liquid film spray	Liquid pressure	PSN		8.0 ~ 50		–	520 ~ 2500	64
	Clog-resistant nozzle	Full cone spray	Liquid pressure & Liquid siphon	SETOJet SETO-SD	External mixing Outer air type	2.0 ~ 95	ℓ/hr	-	36 ~ 230	67 70
Blower	Ultra-low pressure nozzle	Flat spray	Liquid pressure	BAVV	Internal mixing Inner air type	9.0 ~ 123	ℓ/hr	60	76 ~ 254	80
		Full cone spray	Liquid pressure	LSIM	Internal mixing Outer air type	~1000	ℓ/hr	20	1500 ~ 6000	82
Steam	Steam driven nozzle	Full cone spray	Liquid pressure	JOKIJet®	External mixing Outer air type	10 ~1200	ℓ/hr	-	-	84

[Spray conditions]
Small capacity Fine fog nozzle: spray capacity at air press. 0.3MPa & liquid press. 0.1-0.3MPa, air consumption at air press. of 0.2-0.4MPa
Medium-Large capacity Fine fog nozzle: spray capacity at air press. 0.3MPa & liquid press. 0.2-0.5MPa, air consumption at air press. of 0.3-0.4MPa
Semi-fine/Semi-coarse fog nozzle (except PSN): spray capacity and air consumption at air press. 0.1-0.4MPa & liquid press. 0.07-0.7MPa
PSN nozzle: spray capacity and air consumption at air & liquid press. 0.1-0.4MPa, slit length 1000mm, slit opening 0.05mm
Clog-resistant nozzle: spray capacity and air consumption at air press. 0.3MPa & liquid press. 0-0.05MPa
Ultra-low pressure BAVV nozzle (Fine fog): spray capacity at liquid press. 0.02-0.04MPa, air consumption at air press. of 0.02MPa
Ultra-low pressure LSIM nozzle (Semi-fine fog): spray capacity at liquid press. 0-2MPa, air consumption at air press. of 0.02-0.06MPa
Steam-driven nozzle: spray capacity at steam press. 0.1-0.6MPa, liquid press. 0.1-0.5MPa