NOZZLE FEATURES

Spray nozzles are used in a wide array of industrial applications ranging from odour control and dust suppression through to metal paint pre-treatment and fire protection systems. This extreme versatility is due to the ability of the nozzles to operate over a wide range of spraying conditions. Nevertheless, whatever the application, the function of the nozzle still remains the same - to control the flow of liquid, atomise liquid into droplets, distribute the droplets in a specific pattern and generate impact over a specific surface area. The following section is a step-by-step guide to the characteristics of spray nozzles and will help you select the correct nozzle to suit your application. A summary chart is provided on page 8.

CONTROL OF LIQUID FLOW

The flow rate (capacity) of a fluid through a nozzle is affected by a number of factors including pressure, specific gravity and viscosity of the fluid.

Pressure

Assuming that all factors remain constant, increasing pressure will result in an increase in flow through a nozzle.

For the majority of industrial nozzles, this is expressed as:

$$Q1 = Q2 * \sqrt{\frac{P1}{P2}}$$

Where Q represents flow rate and P represents pressure.

Most Lurmark nozzles are calibrated at 3 bar pressure with water, however, should you require the flow rate of a nozzle at a specific pressure, please consult us at Lurmark and we will be happy to calibrate your nozzle under laboratory conditions.

Movement of the liquid through pipe and fittings will create resistance in the flow of liquid towards the nozzle and as a result, pressure loss will occur. To ensure that the correct pressure is maintained at the spray tip the pipe must be of adequate diameter (see Table 2) and pressure losses must be taken into account when designing systems (see page 47).

Specific Gravity

The specific gravity or density of a liquid represents the ratio of a mass of given volume of liquid to the mass of the same volume of water, i.e.:

$$\text{LIQUID FLOW} = \text{Water flow rate} \times \frac{1}{\sqrt{\text{Specific}}}$$

Generally, the higher the specific gravity of a liquid the smaller the flow rate of liquid through the nozzle. The following conversion factors can be used to calculate specific gravity effects (Table 1).

Table1

SG CONVERSION TABLE

SG	$\sqrt{SG}$	$\frac{1}{\sqrt{SG}}$
0.70	0.84	1.20
0.80	0.89	1.12
0.90	0.95	1.05
1.00	1.00	1.00
1.10	1.05	0.95
1.20	1.10	0.91
1.30	1.14	0.88
1.40	1.18	0.85
1.50	1.23	0.82
1.60	1.27	0.79

Viscosity

The viscosity of a liquid is a measure of the extent to which the liquid resists a tendency to flow. In general, increased pressure is required to atomise more viscous liquids resulting in sprays with a smaller angle compared with water alone.

Nozzle design governs the extent of this effect, but in general, as viscosity increases, so the flow rate of hollow and full cone nozzles is increased and conversely, the flow of flat sprays are decreased.

Surface Tension

Surface tension is the condition existing at the free surface of a liquid resembling the properties of an elastic skin under tension. This tension is a result of the intermolecular forces exerting an unbalanced inward pull on the individual surface molecules.

Surface tension affects the development of the liquid sheet and hence directly influences minimum operating pressures, droplet-size and spray angle as summarised on page 8.

Temperature

Temperature influences liquid viscosity, specific gravity and surface tension, and can affect the performance of spray through a nozzle. Data presented in this handbook are based on water only applications at room temperature - for more extreme conditions, please consult Lurmark.

Atomisation

Droplet formation (atomisation) begins when a liquid is forced through a hydraulic nozzle under pressure so that the liquid forms a thin sheet that subsequently breaks-up into droplets. Each nozzle produces a range of droplet-sizes, known as the droplet spectra or drop-size distribution. Droplet-size is measured in microns (μm).

In general, the range of droplets produced by a nozzle depends on nozzle design - the smallest droplets, ideal for applications such as odour control and dust suppression, being produced by air atomising nozzles and the

RELATIVE DROPLET SIZE BY NOZZLE TYPE

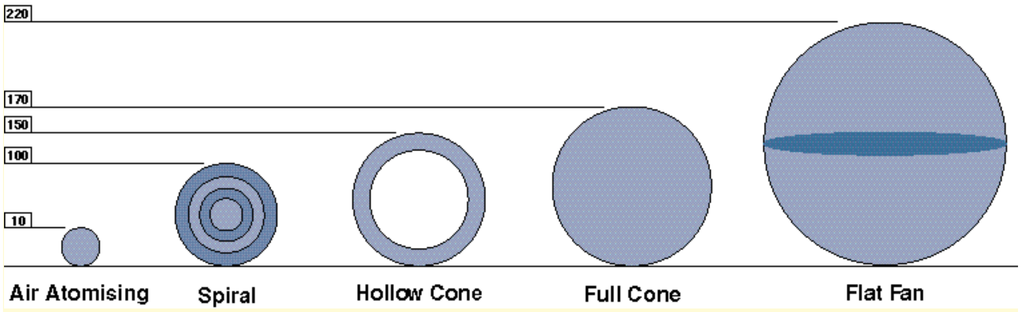


Table 2 - **PRESSURE LOSS OF WATER THROUGH SCHEDULE 40 STEELPIPE**

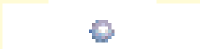
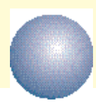
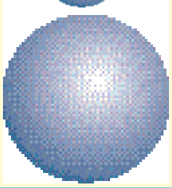
FLOW IN L/min	PRESSURE DROP IN BAR FOR VARIOUS PIPE SIZES (IN 10mm LENGTH)														
	1/8"	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	3 1/2"	4"	5"	6"	8"
1.0	0.07															
1.5	0.16	0.04														
2.0	0.26	0.06														
2.5	0.40	0.08														
3.0	0.56	0.12	0.03													
4.0	0.96	0.21	0.05	0.02												
6.0	2.0	0.45	0.10	0.03												
8.0	3.5	0.74	0.17	0.05	0.01											
10.0	-	1.2	0.25	0.08	0.02											
12.0	-	1.7	0.35	0.11	0.03											
15.0	-	2.6	0.54	0.17	0.04	0.01										
20.0	-	-	0.92	0.28	0.07	0.02										
25.0	-	-	1.2	0.45	0.11	0.03										
30.0	-	-	2.1	0.62	0.15	0.04	0.01									
40.0	-	-	-	1.1	0.25	0.08	0.02									
60.0	-	-	-	-	0.54	0.16	0.04	0.02	0.006							
80.0	-	-	-	-	0.93	0.28	0.07	0.03	0.009							
100.0	-	-	-	-	-	0.43	0.12	0.05	0.010							
115.0	-	-	-	-	-	0.58	0.14	0.06	0.015							
130.0	-	-	-	-	-	0.72	0.18	0.08	0.02	0.010						
150.0	-	-	-	-	-	-	0.23	0.10	0.03	0.012						
170.0	-	-	-	-	-	-	0.29	0.13	0.04	0.016						
190.0	-	-	-	-	-	-	0.36	0.16	0.05	0.02						
230.0	-	-	-	-	-	-	0.50	0.23	0.07	0.03	0.009					
260.0	-	-	-	-	-	-	-	0.32	0.09	0.04	0.01					
300.0	-	-	-	-	-	-	-	0.38	0.11	0.04	0.02	0.007				
340.0	-	-	-	-	-	-	-	0.50	0.14	0.06	0.02	0.009				
380.0	-	-	-	-	-	-	-	0.61	0.18	0.07	0.03	0.01				
470.0	-	-	-	-	-	-	-	-	0.28	0.11	0.04	0.02	0.009			
570.0	-	-	-	-	-	-	-	-	0.39	0.15	0.05	0.03	0.01			
750.0	-	-	-	-	-	-	-	-	0.64	0.26	0.09	0.04	0.02	0.007		
950.0	-	-	-	-	-	-	-	-	-	-	0.14	0.06	0.03	0.01		
1150.0	-	-	-	-	-	-	-	-	-	-	0.19	0.09	0.05	0.02		
1500.0	-	-	-	-	-	-	-	-	-	-	-	0.16	0.08	0.03	0.01	
1900.0	-	-	-	-	-	-	-	-	-	-	-	-	0.13	0.04	0.02	
2800.0	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	0.03	0.009
3800.0	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16	0.06	0.02
7500.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.23	0.06

Recommended flow rate ranges shown in blue

largest, ideal for washing and cleaning being produced by flat fans.

There are a number of different ways to describe droplet-size information - these are summarised in Table 4. To compare droplet-size from one nozzle to another, droplet diameters derived using the same assessment method must be used.

Should you need specific droplet-size information, please contact us at Lurmark - we have a droplet analyser which can be used to test nozzles.

Degree of Atomisation	Droplet Size (Microns)	Relative Size
Fog	Up to 20	
Fine Mist	20 - 100	
Fine Drizzle	100 - 250	
Light Rain	250 - 1000	
Thunderstorm Rain	1000 - 4000	

Viscosity and surface tension are the two main factors that influence droplet-size. Generally as viscosity or surface tension is increased, so the forces required to generate droplets are increased, leaving less energy available for atomisation. Hence viscous liquids or those with high surface tension tend to form more coarse droplets. Moreover, as flow rate increases an increase in droplet-size is also observed. In the case of air atomisers, increasing the shear velocity of the liquid will decrease droplet size.

Spray Pattern

There are a number of diferent basic patterns that can be produced by spray nozzles, as summarised with each flow rate chart. It is more than likely that more than one spray pattern would meet your application requirements - please consult our technical experts for more information.

Spray angle, coverage and impact

Using trigonometry, the spray angle, measured close to the nozzle orifice, and spray distance can be used to calculate the theoretical area that will be covered by spray (see diagram on page 8). In practice, as droplets move away from the nozzle orifice, they are influenced by gravity and air resistance. As a consequence the actual coverage achieved by a nozzle is substantially less than the theoretical value.

TABLE 3

SUMMARY OF FACTORS AFFECTING NOZZLE PERFORMANCE

This chart provides a summary of the factors affecting nozzle performance and is applicable to most spraying scenarios. However, results may vary for nozzles used under certain conditions.

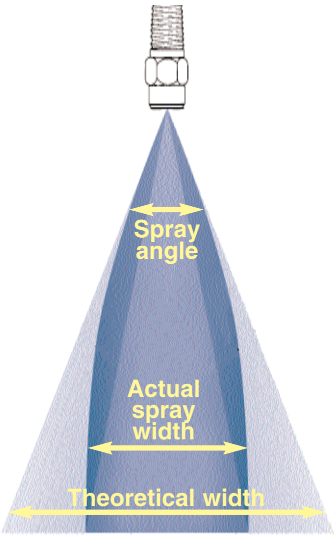
Please contact our technical experts for more information on your specific applications.

	PRESSURE INCREASE	SPECIFIC GRAVITY INCREASE	VISCOSITY INCREASE	SURFACE TENSION INCREASE	TEMPERATURE INCREASE
FLOW RATE	▲	▲	●	NEGLIGIBLE	●●
FLOW ANGLE	▲*	NEGLIGIBLE	▼	▼	▲
DROPLET SIZE	▼	NEGLIGIBLE	▲	▲	▼
VELOCITY	▲	▼	▼	NEGLIGIBLE	▲
IMPACT	▲	NEGLIGIBLE	▼	NEGLIGIBLE	▲
WEAR	▲	NEGLIGIBLE	▼	NEGLIGIBLE	●●

●● Depends on the spray nozzle used and liquid being sprayed

● Full Cone and hollow cone increase, flat fan decreases.

▼ Decrease ▲ Increase * Depending on nozzle type



Pressure, viscosity and surface tension all influence the spray angle. These effects are summarised in Table 3.
Spray impact can be described as the impingement of spray onto a target surface.

Generally, the impact of droplets from flat fan, evenspray and straight jet will be high compared with those produced from deflector, hollow cone and air atomising sprays.
Using the formula below, theoretical impact value can be obtained.
However, both viscosity and pressure will significantly affect impact (summarised in Tables 3 and 5).

TABLE 4

DEFINITIONS OF SOME COMMON SPRAY QUALITY MEASUREMENTS USED WITHIN INDUSTRY

Sauter Mean Diameter (SMD). Also expressed as D_{32}	The diameter of a droplet whose ratio of volume to surface area is equal to that of the total sample. This diameter permits the calculation of the total surface area of an atomised volume of liquid.
Volume Median Diameter (VMD). Also known as (MVD) or $Dv_{0.5}$, (MMD)	A number which divides the spray into two equal parts by volume. eg A VMD value of 30 microns would mean the spray pattern contains half the volume of droplets with diameters of 30 microns and below and half above 30 microns.
Number Median Diameter (NMD) $DN_{0.5}$	The average diameter of a drop without reference to volume. The NMD ratio reflects the uniformity or span of drop production.
Arithmetic Mean (D_{21})	The average of the diameters of all the droplets in the sample.
Volume Mean (D_{31})	The diameter of a droplet whose volume if multiplied by the number of droplets will equal the total sample volume.
Surface Mean (D_{20})	The diameter of a droplet whose surface area if multiplied by the total number of droplets, will equal the total surface area of the sample.
Surface Median Diameter ($D_{A0.5}$)	The diameter which divides the surface area of the droplets into two equal halves
Volume Mean Diameter ($D_{V0.5}$)	The diameter of a droplet whose ratio of volume to diameter is equal to that of the entire sample.

TABLE 5

Spray Pattern Type	Spray Angle Degrees	% Impact per cm^2 of Theoretical Total Impact*
Flat Fan	15	30%
	25	18%
	35	13%
	40	12%
	50	10%
	65	7%
	80	5%
Full Cone	15	11%
	30	2.5%
	50	1%
	65	0.4%
	80	0.2%
	100	0.1%
Hollow Cone	60-80	1-2%

**30cm distance from nozzle*

$$N/cm^2 = 0.327 \times \text{Flow rate (L/min)} \times \sqrt{\text{Spraying Pressure (bar)}}$$