Nozzle Features

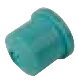
This section provides information on the factors that influence spray characteristics: liquid flow, spray pattern, angle, droplet size and spray impact. It also offers advice on choosing the of nozzle material according to the pressure, abrasion and chemical tolerance that is needed.

The table on pages 6 and 7 shows the different types of Hypro nozzles, their spray characteristics, and the applications that they are typically suited to.

For advice on nozzle choice please call **+44 (0) 01954 260097**
or e-mail **info@hypro-ind.co.uk**

Nozzle Application Chart

If you cannot find the nozzle you are looking for, please ask. Many of our nozzles are made to order and we can often supply additional flow rates, spray angles and materials to those published if your application demands them.

Spray Pattern	Type of Nozzle		Nozzle Characteristics	Types of Application: Washing / rinsing	Chemical spraying	Surface treatment	Environment control / misting
FLAT FAN	CM Series		A high impact spray of coarser droplets. Constructed with a threaded hex body for ease of fitting. Non-clogging, one piece design. Also available as a shorter "stubby" (HCM) option, that is ideal where space is restricted.	✓	✓	✓	
	SN Series		A high impact spray of coarser droplets. Non-clogging one piece construction with precision machined deflector plate for maximum impact and washing effectiveness.	✓			
	F/E Series		A medium impact spray available in a range of droplet spectrums. Single piece construction. Flanged for use in a threaded holder with a cap nut or in a bayonet cap with locked spray fan orientation.	✓	✓		
	AN Series		A medium impact wide angled spray of coarser droplets. One piece design deflects spray at 75° from inlet orifice. Good clog resistance makes AN nozzles suitable for use with a wide range of fluids.	✓	✓	✓	
	Impact-Pro HP Series		A very high impact spray for efficient pressure washing. One piece design with male thread. The hex body makes for fast fitting without the risk of damage.	✓			
	XT Series		A coarse spray designed to be projected up to 5 metres from a moving vehicle creating a wide spray swath without a spray boom. Useful for spraying where there are obstacles.		✓	✓	
	C Series		A high impact coarse spray designed specifically for use in continuous metal casting. Three piece construction with internal deflector produces a uniform spray. Flanged connection fits 1" cap nut.			✓	
FULL CONE	L Series		A medium / fine quality spray with circular spray pattern and uniform droplet size. Female or male thread options. Designed for cooling in the steel industry.			✓	✓
	TN / FCX Series		A low flow, medium quality spray. Flange connection for use with a threaded nozzle holder and cap nut or in a bayonet cap. Standard 70° or wide (W) 110° angle options. Metal (TN) or polyacetal (FCX) options.	✓		✓	✓
	FN Series		A high flow medium / fine quality spray. One piece construction with an internal swirl core to generate full cone or square spray pattern. Threaded hex body for ease of fitting.	✓	✓	✓	✓
	GN Series		A medium/fine quality spray. Male or female threaded options. Right angle design with square body for easy fitting. Three piece construction allows removal of nozzle for cleaning.	✓	✓	✓	✓
	FP Series		A low flow medium / fine quality spray suitable for low volume spraying applications. Hex body with male thread. Internal impeller creates full cone pattern.	✓	✓		✓
HOLLOW CONE	HAF / HCX Series		A low flow nozzle producing a fine mist of droplets. Flanged fitting fits threaded nozzle holder and cap nut assembly or standard hollow cone bayonet caps. Filter options available.		✓	✓	✓
	H Series		A medium flow nozzle producing a mist of droplets. Right angle design with square body for easy fitting. Two piece design with no internal parts to reduce the risk of blockage and smooth flow to minimise nozzle wear.			✓	✓
	FS Series		A medium flow misting nozzle producing a mist of spray droplets. One piece body with an internal spiral core. Hex body with a range of male or female thread sizes.	✓		✓	✓
	Misting Nozzles HV/AF/AMF		Very low flow nozzles producing a mist of very small spray droplets. Options that are designed for higher pressure (HV) and medium pressure (AF and AMF) spraying		✓	✓	✓
ROTATING STREAM	Sudden Impact		A single solid stream slowly traces a rotating pattern for ultra high pressure concentrated cleaning action. Highly durable tungsten carbide flow patternator and corrosion resistant 304 Stainless steel or brass housing.	✓			
FOGGING	Vapro Series		Fine fog achieved by mixing compressed air and fluid for the lowest fluid useage and minimal wetting. Available with shut-off and clean out options in a very wide range of flows and spray distribution patterns.			✓	✓

Applications are for guidance only, for advice on your specific situation, please call us on +44 (0)1954 260097 or e-mail info@hypro-ind.co.uk

Impact	Flow	Common Droplet Spectrum*	Connection			Spray Angles (Varies with pressure)	Max flow	Polyacetal	PVDF	Polyprop	PVC	Brass	S Steel 303	S Steel 316	S Steel 416	Page	Type of Nozzle
			Flanged	Thread	Push Fit												
High	High	Fine/ Coarse		M	✓	0-110° at 3 bar	758 l/min at 30 bar	✓	✓			✓		✓		14,15	CM Series
High	High	Coarse		M		15-50° at 3 bar	144 l/min at 10 bar					✓	✓	✓		16	SN Series
Med	Med	Fine/ Coarse	✓			0-110° at 3 bar	25 l/min at 30 bar	✓	✓			✓	✓			17	F/E Series
Med	High	Coarse	✓	M		80-145° at1.5 bar	410 l/min at 4 bar	✓			✓	✓		✓		18,19	AN Series
Very High	High	Coarse		M		0-40° at 10 bar	64 l/min at 200 bar								✓	20	Impact-Pro HP Series
High	High	Coarse		M		110° at 3 bar	109 l/min at 5 bar							✓		21	XT Series
High	Med	Coarse	Fits 1" Cap Nut			80-100° at 3 bar	48 l/min at 3 bar					✓				22	C Series
Med/ High	Med	Med/ Fine		M/F		65/90° at 3 bar	22 l/min at 7 bar					✓	✓	✓		24	L Series
Med	Low/ Med	Med	✓			70°-110° at 3 bar	17 l/min at 10 bar	✓				✓		✓		25	TN / FCX Series
Med	High	Med/ Fine		M/F		30-110° at 3 bar	273 l/min at 10 bar					✓	✓	✓		26	FN Series
Med	Med	Med/ Fine		M/F		70° at 3 bar	28 l/min at 10 bar					✓	✓			27	GN Series
Low	Low	Med/ Fine		M		45-120° at 1 bar	14 l/min at10 bar		✓							28	FP Series
Low	Low/ Very Low	Fine	✓			70°-110° at 3 bar	10.8 l/min at 10 bar	✓				✓		✓		30	HAF / HCX Series
Low	Med	Fine		M/F		70°-110° at 3 bar	219 l/min at 10 bar					✓		✓		31	H Series
Low	Med	Fine		M/F		80° at 3 bar	85 l/min at 10 bar					✓		✓		32	FS Series
Low	Very Low	All Mist		M	✓	80-105° (3-7 bar)	12 l/hour at 80 bar	✓								33	Misting Nozzles HV/AF/AMF
High	High	Stream		F		24-30° (50-200 bar)	19.32 l/min at 200 bar					✓	✓			34	Sudden Impact
Low	Very Low	Very Fine		F		10° - 80° (1-6 bar)	1.4-280 l/hour at 1-6 bar							✓		36	Vapro Series

* See page 10. Droplet size varies depending on nozzle size and pressure.

Nozzle Features

A nozzle is used to meter liquid flow, atomise a liquid into droplets, distribute the droplets into a spray pattern and create impact on the target.

Nozzle choice is made based on liquid characteristics and the flow rate, operating pressure, spray pattern, spray angle, droplet size and impact that is required.

The material properties needed for chemical, pressure and abrasion tolerance must also be considered.

An understanding of these factors and their inter-relationships will help to design a spraying system and select the nozzle that delivers a liquid most effectively to its target.

Liquid characteristics and flow rate

This chart shows how changes in liquid properties generally affect the spray that is generated. Each of these relationships is then considered in more detail below.

Change in Liquid Properties	Effect on Spray Characteristics					
	Flow Rate	Spray Angle	Droplet Size	Droplet Velocity	Spray Impact	Nozzle Wear
a) Pressure Increase	▲	Depends on nozzle & liquid	▼	▲	▲	▲
b) Specific Gravity Increase	▼	Negligible	Negligible	▼	Negligible	Negligible
c) Viscosity Increase	▲ Full/ Hollow Cone ▼ Flat Fan	▼	▲	▼	▼	▼
d) Surface Tension Increase	Negligible	▼	▲	Negligible	Negligible	Negligible
e) Temperature Increase	Depends on nozzle & liquid	▲	▼	▲	▲	Depends on nozzle & liquid

▼ Decrease ▲ Increase

a) 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:

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

Where Q1 = flow at P1 (pressure)
Where Q2 = flow at P2 (pressure)

Most Hypro nozzles are calibrated at 3 bar pressure with water at 20°C. Generally a minimum pressure of 1 bar is needed to generate an effective spray pattern.

Movement of the liquid through pipe and fittings will create resistance in the flow of liquid and as a result, pressure loss will occur. This must be taken into account when designing a spraying system or spray bar.

b) 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:

$$\text{Liquid Flow} = \text{Water Flow Rate} \times \sqrt{\frac{1}{\text{Specific Gravity of Liquid}}}$$

Generally, the higher the specific gravity of a liquid the lower the flow rate of liquid through the nozzle. The following conversion factors can be used to calculate the effect of specific gravity on flow. For a known specific gravity value use the conversion factor to multiply the flow shown in the nozzle tables on pages 13-36.

Specific Gravity	Conversion Factor
0.70	1.20
0.80	1.12
0.90	1.05
1.00	1.00
1.10	0.95
1.20	0.91
1.30	0.88
1.40	0.85
1.50	0.82
1.60	0.79
1.70	0.77

c) 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 than water sprayed alone.

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

d) Surface Tension

Surface tension is the force that pulls the surface molecules of a fluid inwards.

Higher surface tension affects the development of the liquid sheet, reducing the spray angle and increasing droplet size.

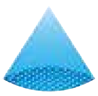
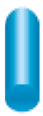
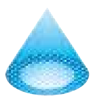
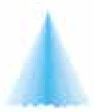
e) Temperature

A rise in temperature reduces liquid viscosity, specific gravity and surface tension, and therefore increases spray angle, velocity and impact whilst reducing droplet size.

Spray Pattern

A range of different mechanisms are employed to produce different spray patterns and spray characteristics. Often there is more than one option. Please ask our experts for advice in the best one to choose.

Different mechanisms will achieve different spray patterns as described below. Selecting the right one will achieve the coverage of the target and the impact required within the constraints of flow and pressure of the spraying situation.

	Spray Pattern	Fluid Creation Mechanism	Description	Used For	Comment
	Flat Fan: Tapered see pages 14-22	Liquid is forced through an eliptical orifice to form a sheet of spray that breaks into ligaments and then droplets.	A tapering spray footprint available in a wide range of angles and flows.	Washing, rinsing and chemical application.	Overlap tapering patterns by 50% to achieve even spray coverage along a spray bar. Adjust the spray distance to achieve a precise overlap.
	Flat Fan: Even Spray see pages 14-22	Liquid is forced through an oval orifice to form a sheet of spray that breaks into ligaments and then droplets or is atomised by impacting onto a curved deflector plate.	A non-tapering spray footprint. Available in a wide range of spray angles and flows.	Washing, rinsing and surface treatments including high pressure nozzles used at up to 200 bar.	If aligned along a spray bar, spray patterns must join edge to edge for an overall even pattern.
	Solid Stream see pages 14,15,17,20	Internal geometry creates a solid stream.	A Solid stream with no droplet atomisation for higher impact spraying.	High impact cleaning.	Achieves the maximum possible impact on the target for a given flow.
	Full Cone see pages 24-28	The internal geometry swirls fluid and mixes it with a centre stream to produce a filled circular or square spray footprint.	A conical spray with uniform distribution often used at higher flow rates.	Washing, rinsing and surface treatment.	The GN nozzle option diverts flow at a right angle without an internal vane, thereby reducing the risk of blockage.
	Hollow Cone see pages 30-34	The internal geometry swirls fluid into a circular ring spray pattern. Atomisation occurs at low pressures.	A lower energy ring of spray, useful for low flow, low impact applications.	Surface treatment and environmental spraying and misting.	The H series nozzle option diverts flow at a right angle without an internal vane, thereby reducing the risk of blockage.
	Air Atomising see page 36	Fluid and compressed air are combined, with mixing taking place either inside or outside the nozzle.	A very fine spray with low flow rates. Flat fan or full cone patterns make clouds of spray of different shapes and sizes.	Environmental control such as cooling, dust suppression, fire suppression or fine surface coating.	Precise control of the liquid flow is possible to produce very fine mists (fog) that barely wet a surface.

Nozzle Features

Spray Droplet Size

Droplet size and distribution within the spray varies between nozzle types, affecting their suitablility for different applications. Smaller droplets have a greater collective surface area than larger droplets, making them suitable for applications that require good spray coverage. Larger droplets often come with more velocity, making them suitable for cleaning and washing tasks.

For a given nozzle the droplet size can vary greatly depending on the flow and pressure being deployed. Some typical VMDs for different nozzle types are shown below:

Droplet size is measured in microns (one thousandth of a mm) and can be described in a number of different ways.

Volume Median Diameter (VMD)

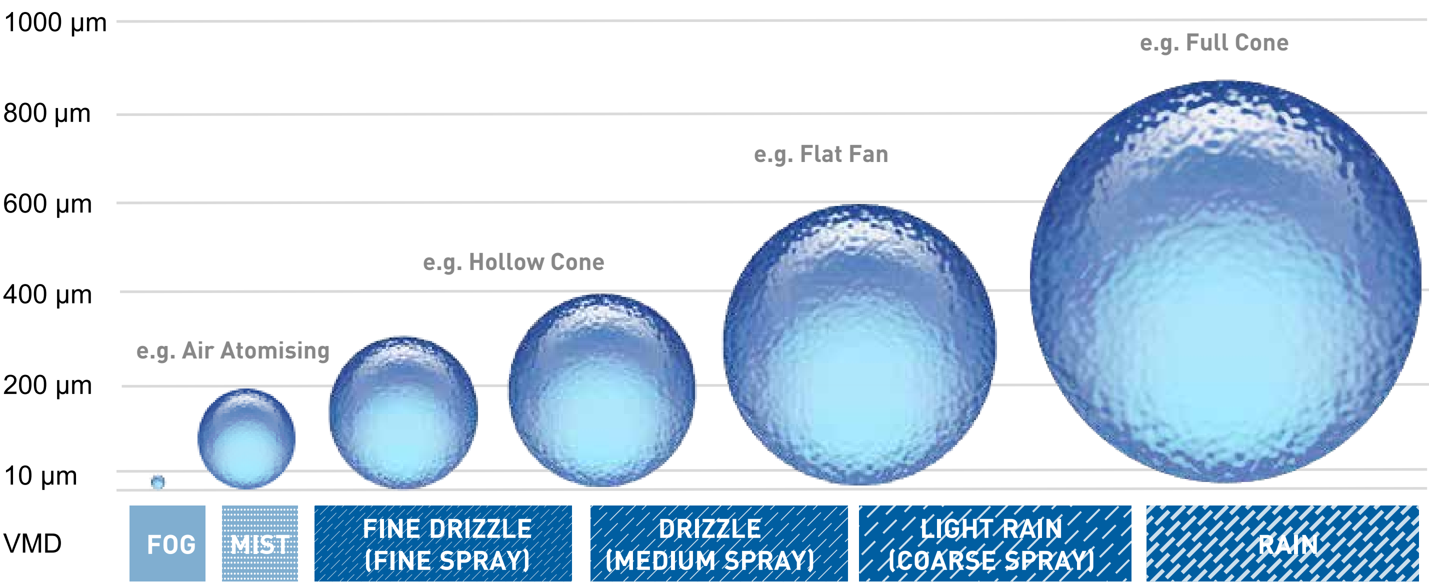
This is a diameter where 50% of the volume of spray contains droplets larger than the VMD and 50% of the volume contains smaller droplets.

Number Median Diameter (NMD)

This is the diameter where 50% of the drops by number are larger and 50% smaller.

Sauter Mean Diameter (SMD)

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.



Spray Impact

The spray impact will depend on the spray pattern distribution, the pressure and the distance to the target. A narrower spray angle will generate more impact than a wide one at a given pressure and distance.

Generally a higher impact will improve cleaning but can be detrimental to spray coverage as droplets bounce off the surface.

Using the formula below the theoretical impact value of liquid for a straight stream can be calculated:

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

Impact of Different Spray Patterns

Spray Pattern Type	Spray Angle	Unit Impact per cm² as a Percentage 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	80°	1 - 2%

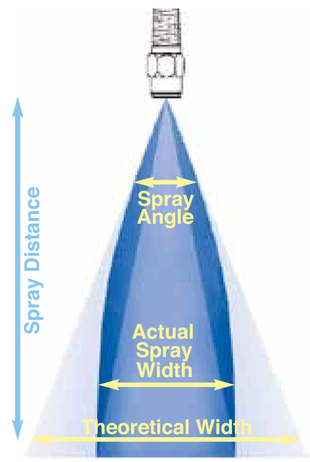
* at 300mm from nozzle.

Spray Angle

The theoretical spray width and therefore the area covered by the spray can be calculated using trigonometry. A table of these calculations is shown below.

In practice, the farther droplets move away from the nozzle orifice, the more they are influenced by gravity and air resistance. So the actual width and coverage is less than the theoretical value. As spray viscosity increases, the spray angle drops off more steeply.

Practically this means that it is useful to be able to adjust the nozzle to get the spray pattern just right.



Theoretical spray coverage

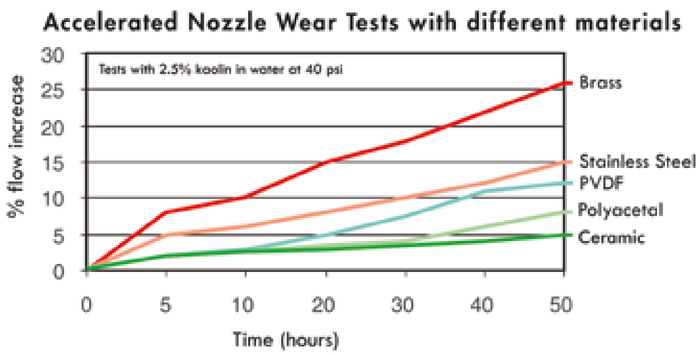
Spray Angle Degree	Theoretical width (mm) at different distance (mm) from the spray nozzle orifice													
	50	100	150	200	250	300	350	400	450	500	600	700	800	900
5	4	9	13	18	22	26	31	35	39	44	52	61	70	79
15	13	26	40	53	66	79	92	105	116	132	158	184	211	237
25	22	44	67	89	111	133	155	177	200	222	266	310	355	399
30	27	54	80	107	134	161	188	214	241	268	322	375	429	482
35	32	63	95	126	158	189	221	252	284	315	378	441	505	568
40	36	73	109	146	182	218	255	291	328	364	437	510	582	655
45	41	83	124	166	204	249	290	331	373	414	497	580	663	746
50	47	93	140	187	233	280	326	373	420	466	560	653	743	833
65	64	127	191	255	319	382	446	510	573	637	765	892	1020	1150
70	70	140	210	280	350	420	490	560	630	700	840	980	1120	1260
75	77	154	230	307	384	460	537	614	691	767	921	1070	1230	1380
80	84	168	252	336	420	504	587	671	755	839	1010	1180	1340	1510
85	92	183	275	367	458	550	641	733	825	916	1100	1280	1470	1650
90	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800
100	119	238	358	477	596	715	834	953	1070	1190	1430	1670	1910	2150
110	143	286	429	571	714	857	1000	1140	1290	1430	1710	2000	2290	2570
120	173	346	520	693	866	1040	1210	1390	1560	1730	2080	2430	-	-

Nozzle Material Properties

Pentair manufacture nozzles from a wide range of materials chosen for their resistance to abrasion, temperature, pressure and chemical attack. Our standard materials are polyacetal, PVDF, brass and stainless steel which are suitable for the majority of applications. Many other options are also available for particularly harsh spraying environments including exotic alloys.

Abrasion Resistance

Abrasion of a nozzle orifice will increase flow rate and change the performance of the spray pattern as shown in the chart opposite.



Nozzle Features

Chemical Tolerance

Chemicals can render a nozzle inoperable as soon as spraying begins. There are a great many nozzle material/chemical combinations with the consequent risk of incompatibility.

Please consult chemical manufacturer datasheets for the chemicals that you plan to spray or ask us for our experience.

Temperature Tolerance

In general metals are more tolerant of high temperatures than plastics.

Nozzle Material	Maximum Temperature
PVC	58°
Polyacetal	85°
PVDF	150°
Brass	234°
Stainless Steel	430°

Nozzle Maintenance

Spray nozzles require regular inspection and cleaning.

Generally once spray nozzles have worn to the point where their flow rate exceeds 110% of datum flow rate they should be replaced. A visual check should be carried out for physical damage and spray patternation at every scheduled shutdown or sooner, depending on the chemicals being used.

When dissassembling and cleaning a nozzle, do not use wire or a pin to poke the nozzle orifice.

Soaking then cleaning with an airline or soft brush is the recommended cleaning technique. Avoid overtightening nozzles as this can also damage the orifice.

Some typical nozzle failures, causes and remedies are described below:

Problem	Probable Causes	Remedy
Restriction to flow	Dirt or other particles lodged in nozzle orifice	Clean with an air line or soak in appropriate solution overnight. Clean filter
	Caking as dried solids build up	Replace nozzle
Spray patternation incorrect	Dirt or other particles lodged in nozzle orifice	Clean with an air line or soak in appropriate solution overnight. Clean filter
	General nozzle wear	Replace nozzle
	Temperature varies from 20°C	Decrease/increase temperature or increase/ decrease pressure
	Corrosion	Replace nozzle
	Accidental damage	Replace nozzle
Increased nozzle flow	General nozzle wear	Replace if above 110% of theoretical flow rate.
	Corrosion	Replace nozzle
	Temperature varies from 20°C	Decrease/increase temperature or increase/ decrease pressure
	Accidental damage	Replace nozzle

When inspecting nozzles, first look at the spray pattern to check for evenness. Some visual indicators of different nozzle problems are shown on the right.

Assembly Mistakes

Following cleaning, nozzles may not be reassembled correctly. Lost gaskets, missing swirl plates or over-tightening for example will result in leaking or poor spray patternation.

Clogging

Dirt or other particles may become lodged in the orifice causing flow restriction and affecting the spray patternation.

Corrosion

The nozzle material may breakdown due to the surrounding environment, usually due to chemical attack.

Erosion / Wear

The nozzle orifice may enlarge due to the gradual erosion of material over time. This will have a direct effect on flow, pressure and the spray pattern will deteriorate.

Temperature Damage

Exposure of a nozzle material to temperatures outside its tolerance will change nozzle performance.

Caking

Dried solids may build up around the orifice or surface of the nozzle due to overspray or evaporation, obstructing the nozzle flow.