TECHNICAL REFERENCE
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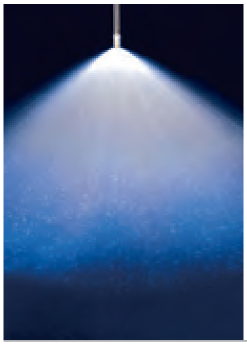
KEY CONSIDERATIONS IN SPRAY NOZZLE SELECTION AND PERFORMANCE OPTIMIZATION

BASIC NOZZLE CHARACTERISTICS

Spray nozzles are precision components designed to yield very specific performance under specific conditions. To help you determine the best nozzle type for your application, the following chart summarizes the performance that each nozzle type is designed to deliver. Visit **youtube.com/sprayingsystems** for video demonstrations of spray patterns.

LASER SHEET IMAGE

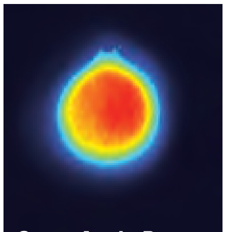


FULL CONE NOZZLES

- Uses a unique internal vane design to produce a solid cone-shaped spray pattern
- Spray pattern consists of medium- to large-sized drops

Typical applications:

- Metal cooling
- Washing/rinsing
- Dust control
- Fire control
- Coating



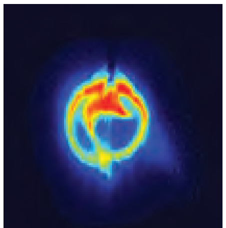
Spray Angle Range:
15° to 125°

FULL CONE (SPIRAL-TYPE) NOZZLES

- Produces a solid cone-shaped spray pattern when the fluid exits the voids in the spiral
- Spray pattern is not as uniform as full cone nozzles with an internal vane
- Spray pattern consists of relatively coarse drops

Typical applications:

- Quenching
- Dust control
- Fire control
- Flue gas desulfurization (FGD)



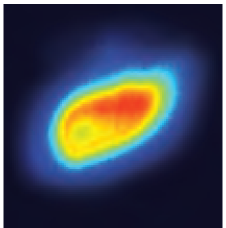
Spray Angle Range:
50° to 170°

FULL CONE (OVAL SPRAY) NOZZLES

- Uses a unique internal vane to produce a solid cone-shaped spray pattern with oval impact area with a width approximately one-half its length
- Spray pattern consists of medium- to large-sized drops

Typical applications:

- Metal cooling
- Air/gas washing
- Dust control
- Fire control



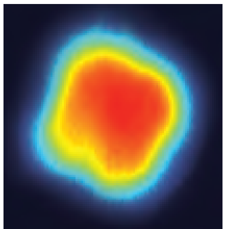
Spray Angle Range:
60° to 105°

FULL CONE (SQUARE SPRAY) NOZZLES

- Uses a unique internal vane to produce a solid cone-shaped spray with square impact area
- Spray pattern is uniform across entire spray area
- Spray pattern consists of medium- to large-sized drops

Typical applications:

- Metal cooling
- Air/gas washing
- Dust control
- Fire control



Spray Angle Range:
52° to 105°

NOTE: The spray pattern images on the right were acquired in our spray laboratories using Laser Sheet Imaging (LSI). LSI images are collected by passing a laser sheet through a cross-section of the spray plume and imaging with a light-filtered camera. The distributions are directly proportional to the surface area distribution of the sprayed material (red: high, blue: low, black: zero). Volume distributions typically are similar to surface area distributions for these nozzles, depending on the local drop size distributions.

LASER SHEET IMAGE

FLAT (EVEN) NOZZLES

- Provides even distribution of medium-sized drops throughout the thin, rectangular spray pattern
- When used on a header, nozzles are positioned for edge-to-edge pattern contact

Typical applications:

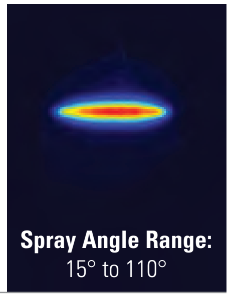
- Descaling
- Metal cooling
- Washing/cleaning
- Coating

FLAT SPRAY (TAPERED) NOZZLES

- Produces a tapered-edge flat spray pattern
- Used on spray headers to provide uniform coverage as a result of overlapping distributions

Typical applications:

- Descaling
- High-pressure cleaning
- Metal cooling

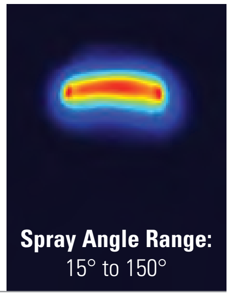


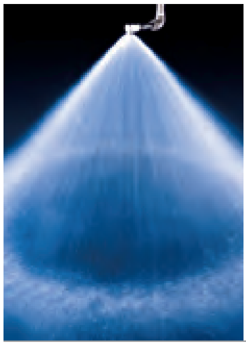
FLAT SPRAY (DEFLECTED-TYPE) NOZZLES

- Uses a deflector surface to form an even flat spray pattern consisting of medium-sized drops
- Large free passage design reduces clogging through the round orifice

Typical applications:

- Washing/cleaning
- Debris removal



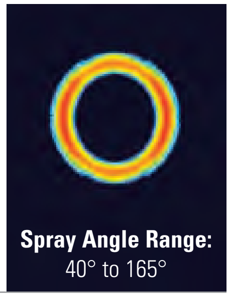


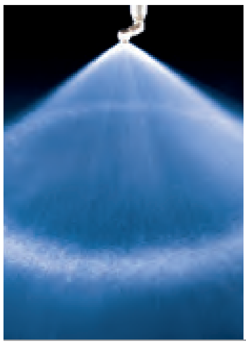
HOLLOW CONE (WHIRLCHAMBER-TYPE) NOZZLES

- Uses a whirlchamber to rotate the fluid and produce a circular spray pattern
- Ideal for use when a combination of small drop size and higher capacity is needed

Typical applications:

- Air, gas and water cooling
- Dust control
- Flue gas desulfurization (FGD)
- Cooling products on conveyors
- Water aeration



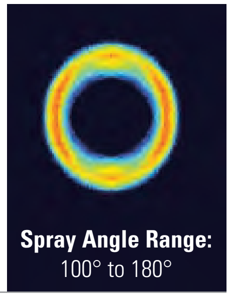


HOLLOW CONE (DEFLECTED-TYPE) NOZZLES

- Uses a deflector cap to form an umbrella-shaped hollow cone pattern

Typical applications:

- Dust control
- Fire control
- Flush cleaning of tube/pipe interiors



BASIC NOZZLE CHARACTERISTICS

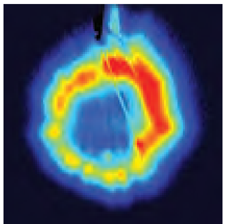
HOLLOW CONE (SPIRAL-TYPE) NOZZLES

- Produces a circular spray pattern when the fluid exits the voids in the spiral
- Drops are slightly coarser than those in other hollow cone sprays
- Provides a high flow rate in a compact nozzle size
- One-piece design produces maximum throughput for a given pipe size

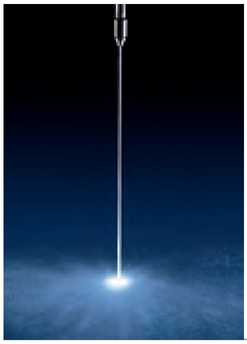
Typical applications:

- Dust control
- Fire control
- Flue gas desulfurization (FGD)

LASER SHEET IMAGE



Spray Angle Range
50° to 180°

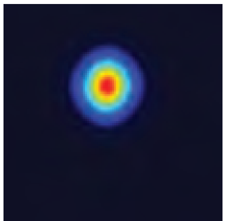


SOLID STREAM NOZZLES

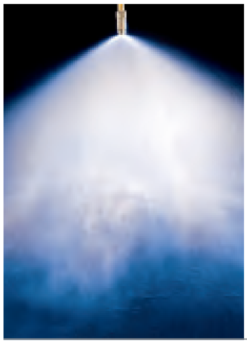
- Produces a solid stream spray with the highest impact per unit area

Typical applications:

- Laminar flow operations
- Washing/cleaning



Spray Angle Range
0°

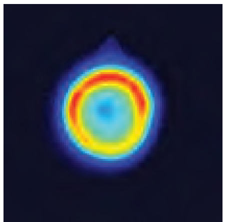


ATOMIZING (HYDRAULIC, FINE MIST) NOZZLES

- Produces a finely atomized, low capacity spray in a hollow cone pattern without use of compressed air

Typical applications:

- Evaporative cooling
- Dust control
- Coating



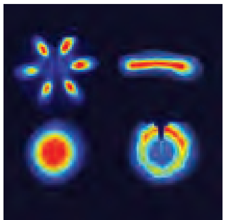
Spray Angle Range
35° to 165°

AIR ATOMIZING AND AIR ASSISTED NOZZLES

- Produces a variety of cone and flat spray patterns through atomization of liquid by compressed air
- Internal mix impingement atomization forms very fine drops

Typical applications:

- Evaporative cooling
- Coating
- Metal cooling



Spray Angle Range
18° to 360°

NOTE: The spray pattern images on the right were acquired in our spray laboratories using Laser Sheet Imaging (LSI). LSI images are collected by passing a laser sheet through a cross-section of the spray plume and imaging with a light-filtered camera. The distributions are directly proportional to the surface area distribution of the sprayed material (red: high, blue: low, black: zero). Volume distributions typically are similar to surface area distributions for these nozzles, depending on the local drop size distributions.

CAPACITY – FLUID CAPACITY FOR HYDRAULIC NOZZLES VARIES WITH SPRAYING PRESSURE

The relationship of pressure and flow with a given orifice is:

$$\frac{Q_1}{Q_2} \sim \frac{(P_1)^n}{(P_2)^n}$$

Q = Flow Rate (in gpm or lpm)
P = Liquid pressure (in psi or bar)
n = Flow exponent

To approximate any unknown flow or pressure, use this formula when the other variables are known. The "n" exponent is used to approximate the ratio of pressure to flow based on the type of spray pattern.

Example:
To determine the flow rate of water for a 1/4G-10 standard full cone nozzle at 150 psi (10 bar), consult the performance charts in this catalog.

You will find that:

- The spray angle is 65°
- Flow (Q_1) at 40 psi = 1.9 gpm
- Pressure (P_1) = 40 psi
- Pressure (P_2) = 150 psi

Solving for Q_2 = 3.5 gpm

$$Q_2 = \frac{Q_1}{(P_1 / P_2)^n} = \frac{1.9 \text{ gpm}}{(40/150)^{.46}}$$

- The spray angle is 65°
- Flow (Q_1) at 3 bar = 7.5 lpm
- Pressure (P_1) = 3 bar
- Pressure (P_2) = 10 bar

Solving for Q_2 = 13 lpm

$$Q_2 = \frac{Q_1}{(P_1 / P_2)^n} = \frac{7.5 \text{ lpm}}{(3/10)^{.46}}$$

FLOW EXPONENT FOR SPECIFIC HYDRAULIC NOZZLE TYPES

Nozzle Type	Exponent "n"
Flat Spray Nozzles – All Full cone Nozzles – Vaneless, 15° and 30° Series Hollow Cone Nozzles – All Solid Stream Nozzles – All Spiral Nozzles – All	.50
Full Cone Nozzles – Standard, Square, Oval and Large Capacity	.46
Full Cone Nozzles – Wide Spray and Wide Square Spray	.44

Visit spray.com/sprayware for online flow rate and spray coverage calculators.

SPECIFIC GRAVITY

All capacity tabulations in this catalog are based on water. Since the specific gravity of a liquid affects its flow rate, tabulated catalog capacities must be multiplied by the conversion factor that applies to the specific gravity of the liquid being sprayed as explained below.

Specific gravity is the ratio of the density of a fluid compared to the density of water. The specific gravity of water is defined as 1. When spraying fluids other than water, specific gravity must be considered in the flow calculations.

$$Q_2 = Q_1(\text{water}) \times \frac{1}{\sqrt{SG}}$$

Using the previous example:

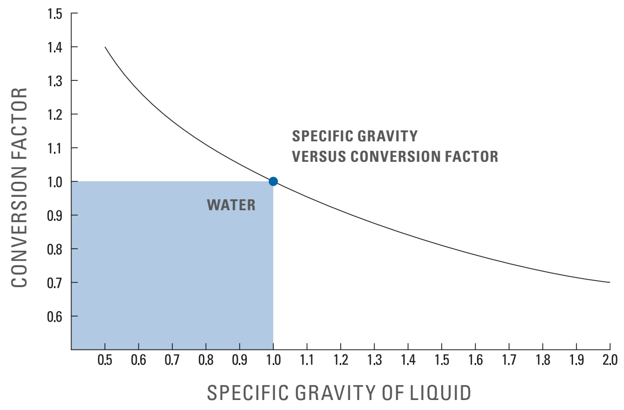
- Fluid sprayed is heavier than water and has a specific gravity of 1.4
- Flow of water at 150 psi = 3.5 gpm
- Heavy fluid (Q_2) = Q_1(water)*1/√1.4

$$Q_2 = \frac{3.5 \text{ gpm} * 1}{\sqrt{1.4}} = 2.95 \text{ gpm}$$

- Fluid sprayed is heavier than water and has a specific gravity of 1.4
- Flow of water at 10 bar = 13 lpm
- Heavy fluid (Q_2) = Q_1(water)*1/√1.4

$$Q_2 = \frac{13 \text{ lpm} * 1}{\sqrt{1.4}} = 11 \text{ lpm}$$

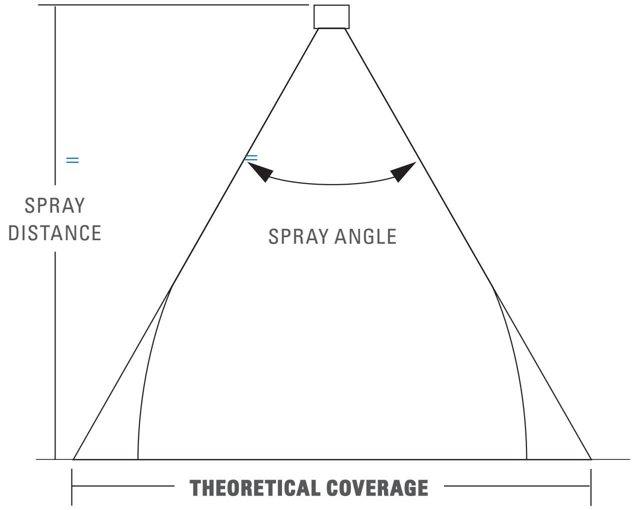
SPECIFIC GRAVITY VERSUS CONVERSION FACTOR



KEY: Conversion factor multiplied by the capacity of the nozzle when spraying water gives the capacity of the nozzle when spraying a liquid with a specific gravity corresponding to the conversion factor. This conversion factor accounts only for the effect of specific gravity on capacity and does not account for other factors affecting capacity.

SPRAY ANGLE AND COVERAGE

Tabulated spray angles indicate approximate spray coverage based on spray or distribution of water. In actual spraying, the effective spray angle varies with spray distance. Liquids more viscous than water form relatively smaller spray angles (or even a solid stream), depending upon viscosity, nozzle capacity and spraying pressure. Liquids with surface tensions lower than water will produce relatively wider spray angles than those listed for water. This table lists the theoretical coverage of spray patterns as calculated from the included spray angle of the spray and the distance from the nozzle orifice. Values are based on the assumption that the spray angle remains the same throughout the entire spray distance. In actual practice, the tabulated spray angle does not hold for long spray distances. If the spray coverage requirement is critical, request data sheets for specific spray coverage data.



Example: A spray nozzle with an angle of 65° spraying 15" (39 cm) from the target provides 19.2" (48.8 cm) of coverage

THEORETICAL SPRAY COVERAGE AT VARIOUS DISTANCES IN INCHES (CM) FROM NOZZLE ORIFICE

Spray Angle	2 in.	5 cm	4 in.	10 cm	6 in.	15 cm	8 in.	20 cm	10 in.	25 cm	12 in.	30 cm	15 in.	40 cm	18 in.	50 cm	24 in.	60 cm	30 in.	70 cm	36 in.	80 cm	48 in.	100 cm
5°	.2	.4	.4	.9	.5	1.3	.7	1.8	.9	2.2	1.1	2.6	1.3	3.5	1.6	4.4	2.1	5.2	2.6	6.1	3.1	7.0	4.2	8.7
10°	.4	.9	.7	1.8	1.1	2.6	1.4	3.5	1.8	4.4	2.1	5.3	2.6	7.0	3.1	8.8	4.2	10.5	5.2	12.3	6.3	14.0	8.4	17.5
15°	.5	1.3	1.1	2.6	1.6	4.0	2.1	5.3	2.6	6.6	3.2	7.9	3.9	10.5	4.7	13.2	6.3	15.8	7.9	18.4	9.5	21.1	12.6	26.3
20°	.7	1.8	1.4	3.5	2.1	5.3	2.8	7.1	3.5	8.8	4.2	10.6	5.3	14.1	6.4	17.6	8.5	21.2	10.6	24.7	12.7	28.2	16.9	35.3
25°	.9	2.2	1.8	4.4	2.7	6.7	3.5	8.9	4.4	11.1	5.3	13.3	6.6	17.7	8.0	22.2	10.6	26.6	13.3	31.0	15.9	35.5	21.2	44.3
30°	1.1	2.7	2.1	5.4	3.2	8.0	4.3	10.7	5.4	13.4	6.4	16.1	8.1	21.4	9.7	26.8	12.8	32.2	16.1	37.5	19.3	42.9	25.7	53.6
35°	1.3	3.2	2.5	6.3	3.8	9.5	5.0	12.6	6.3	15.8	7.6	18.9	9.5	25.2	11.3	31.5	15.5	37.8	18.9	44.1	22.7	50.5	30.3	63.1
40°	1.5	3.6	2.9	7.3	4.4	10.9	5.8	14.6	7.3	18.2	8.7	21.8	10.9	29.1	13.1	36.4	17.5	43.7	21.8	51.0	26.2	58.2	34.9	72.8
45°	1.7	4.1	3.3	8.3	5.0	12.4	6.6	16.6	8.3	20.7	9.9	24.9	12.4	33.1	14.9	41.4	19.9	49.7	24.8	58.0	29.8	66.3	39.7	82.8
50°	1.9	4.7	3.7	9.3	5.6	14.0	7.5	18.7	9.3	23.3	11.2	28.0	14.0	37.3	16.8	46.6	22.4	56.0	28.0	65.3	33.6	74.6	44.8	93.3
55°	2.1	5.2	4.2	10.4	6.3	15.6	8.3	20.8	10.3	26.0	12.5	31.2	15.6	41.7	18.7	52.1	25.0	62.5	31.2	72.9	37.5	83.3	50.0	104
60°	2.3	5.8	4.6	11.6	6.9	17.3	9.2	23.1	11.5	28.9	13.8	34.6	17.3	46.2	20.6	57.7	27.7	69.3	34.6	80.8	41.6	92.4	55.4	115
65°	2.5	6.4	5.1	12.7	7.6	19.1	10.2	25.5	12.7	31.9	15.3	38.2	19.2	51.0	22.9	63.7	30.5	76.5	38.2	89.2	45.8	102	61.2	127
70°	2.8	7.0	5.6	14.0	8.4	21.0	11.2	28.0	14.0	35.0	16.8	42.0	21.0	56.0	25.2	70.0	33.6	84.0	42.0	98.0	50.4	112	67.2	140
75°	3.1	7.7	6.1	15.4	9.2	23.0	12.3	30.7	15.3	38.4	18.4	46.0	23.0	61.4	27.6	76.7	36.8	92.1	46.0	107	55.2	123	73.6	153
80°	3.4	8.4	6.7	16.8	10.1	25.2	13.4	33.6	16.8	42.0	20.2	50.4	25.2	67.1	30.3	83.9	40.3	101	50.4	118	60.4	134	80.6	168
85°	3.7	9.2	7.3	18.3	11.0	27.5	14.7	36.7	18.3	45.8	22.0	55.0	27.5	73.3	33.0	91.6	44.0	110	55.0	128	66.0	147	88.0	183
90°	4.0	10.0	8.0	20.0	12.0	30.0	16.0	40.0	20.0	50.0	24.0	60.0	30.0	80.0	36.0	100	48.0	120	60.0	140	72.0	160	96.0	200
95°	4.4	10.9	8.7	21.8	13.1	32.7	17.5	43.7	21.8	54.6	26.2	65.5	32.8	87.3	39.3	109	52.4	131	65.5	153	78.6	175	105	218
100°	4.8	11.9	9.5	23.8	14.3	35.8	19.1	47.7	23.8	59.6	28.6	71.5	35.8	95.3	43.0	119	57.2	143	71.6	167	85.9	191	114	238
110°	5.7	14.3	11.4	28.6	17.1	42.9	22.8	57.1	28.5	71.4	34.3	85.7	42.8	114	51.4	143	68.5	171	85.6	200	103	229	–	286
120°	6.9	17.3	13.9	34.6	20.8	52.0	27.7	69.3	34.6	86.6	41.6	104	52.0	139	62.4	173	83.2	208	104	243	–	–	–	–
130°	8.6	21.5	17.2	42.9	25.7	64.3	34.3	85.8	42.9	107	51.5	129	64.4	172	77.3	215	103	257	–	–	–	–	–	–
140°	10.9	27.5	21.9	55.0	32.9	82.4	43.8	110	54.8	137	65.7	165	82.2	220	98.6	275	–	–	–	–	–	–	–	–
150°	14.9	37.3	29.8	74.6	44.7	112	59.6	149	74.5	187	89.5	224	112	299	–	–	–	–	–	–	–	–	–	–
160°	22.7	56.7	45.4	113	68.0	170	90.6	227	113	284	–	–	–	–	–	–	–	–	–	–	–	–	–	–
170°	45.8	114	91.6	229	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Visit spray.com/sprayware for online flow rate and spray coverage calculators.

SPRAY DROP SIZE (ATOMIZATION)

Drop size refers to the size of the individual spray drops that comprise a nozzle's spray pattern. Each spray provides a range of drop sizes; this range is referred to as drop size distribution. Drop size distribution is dependent on the spray pattern type and varies significantly from one type to another. The smallest drop sizes are achieved by air atomizing nozzles while the largest drops are produced by full cone hydraulic spray nozzles.

ACTUAL DROP SIZES

- 500 µm
- 1200 µm
- 5500 µm

One inch = 25,400 µm
One millimeter = 1,000 µm
µm = micrometers

Liquid properties, nozzle capacity, spraying pressure and spray angle also affect drop size. Lower spraying pressures provide larger drop sizes. Conversely, higher spraying pressures yield smaller drop sizes. Within each type of spray pattern the smallest capacities produce the smallest spray drops, and the largest capacities produce the largest spray drops.

DROP SIZE BY SPRAY PATTERN TYPE AT VARIOUS PRESSURES AND CAPACITIES

Spray Pattern Type	10 psi (0.7 bar)			40 psi (2.8 bar)			100 psi (7 bar)		
	Capacity		VMD	Capacity		VMD	Capacity		VMD
	gpm	lpm	microns	gpm	lpm	microns	gpm	lpm	microns
Air Atomizing	.005 .02	.02 .08	20 100	.008 8	.03 30	15 200	12	45	400
Fine Spray	.22	.83	375	.03 .43	.1 1.6	110 330	.05 .69	.2 2.6	110 290
Hollow Cone	.05 12	.19 45	360 3400	.10 24	.38 91	300 1900	.16 38	.61 144	200 1260
Flat Fan	.05 5	.19 18.9	260 4300	.10 10	.38 38	220 2500	.16 15.8	.61 60	190 1400
Full Cone	.10 12	.38 45	1140 4300	.19 23	.72 87	850 2800	.30 35	1.1 132	500 1720

Based on a sampling of nozzles selected to show the wide range of possible drop sizes available.

DROP SIZE TERMINOLOGY

Terminology is often a major source of discrepancy and confusion in understanding drop size. To accurately compare drop sizes from one nozzle to another, the same diameters have to be used. Drop size is usually expressed in microns (micrometers). Following are the most popular characteristic diameters and their definitions.

VOLUME MEDIAN DIAMETER (VMD)

also expressed as $D_{V0.5}$ and Mass Median Diameter (MMD)

A means of expressing drop size in terms of the volume of liquid sprayed. The Volume Median Diameter drop size when measured in terms of volume (or mass) is a value where 50% of the total volume of liquid sprayed is made up of drops with diameters larger than the median value and 50% with smaller diameters.

SAUTER MEAN DIAMETER (SMD)

also expressed as D_{32}

A means of expressing the fineness of a spray in terms of the surface area produced by the spray. The Sauter Mean Diameter is the diameter of a drop having the same volume-to-surface area ratio as the total volume of all the drops to the total surface area of all the drops.

NUMBER MEDIAN DIAMETER (NMD)

also expressed as $D_{N0.5}$

A means of expressing drop size in terms of the number of drops in the spray. This means that 50% of the drops by count or number are smaller than the median diameter and 50% of the drops are larger than the median diameter.

More drop size data is available on all types of spray nozzles. For more information, contact your local steel specialist.

IMPACT

Impact is the measure of force imparted on a surface by a spray pattern at a given distance. It can be expressed in several ways. All definitions are derived from the most basic equation of total impact force. This is the force that any flow, at any pressure, is capable of making on a surface. This does not account for orifice shape, nozzle type, fluid properties and other factors.

$$I = K \times Q \times \sqrt{P}$$

Total theoretical impact = constant (based on units) x flow (at pressure P) x square root of pressure (P)

I = total theoretical spray impact

K = constant

Q = flow rate

P = liquid pressure

I	lbs.(f)	kg(f)	Newtons	Newtons
K	.0526	.024	.24	.745
Q	gpm	lpm	lpm	lpm
P	psi	kg/cm^2	bar	MPa

The constant (K), is a unit conversion based on the measurement system used. The conversions are listed in the chart above.

Example:

$I = .0526 \times 10.5 \text{ gpm} \times \sqrt{2500 \text{ psi}}$

I = 27.6 lbs(f)

Contact your local steel specialist for assistance in determining impact in your application.

FACTORS THAT AFFECT IMPACT

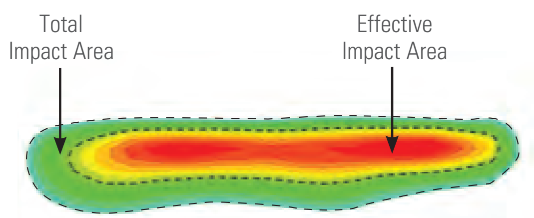
- Loose material and standing liquid both dissipate some portion of the flow energy and can reduce impact
- As spray travels through the air to reach the target surface, drops decelerate and the momentum of the spray is reduced. Nozzle size, pressure, spray style and spray height each play a role in deceleration
- Closer target distances result in higher normalized impact pressure, but also result in smaller coverage area per nozzle
- Increasing pressure will increase total impact. Changes in impact also affect the spray pattern and increase turbulence
- Turbulence has a negative effect on nozzle performance, the service life of the nozzle and header

LATERAL IMPACT AND SPECIFIC IMPACT

Lateral impact, sometimes called lineal impact, is the force per unit length across the spray width. Usually expressed in lb./in. or kg/cm, it shows the volumetric distribution pattern and the evenness of the impact across the spray. It also provides an indication of relative cleaning effectiveness. Flat spray patterns have fairly uniform impact distribution across the effective spray coverage.

Specific impact is the total impact force divided by a given area. Because spray patterns have both an effective impact area, where the majority of the spray hits, and a somewhat larger total impact area, two types of specific impact can be calculated.

- **Average specific impact** is the total impact force divided by the total impact area
- **Maximum specific impact** is the total impact force divided by the effective impact area



Both are expressed in terms of force per unit area. Maximum specific impact is a direct indication of spray intensity applied to a surface and can be used to compare spray effectiveness under various conditions.

OPERATING PRESSURE

The values given in the tabulation sections of this catalog indicate the most commonly used pressure ranges for the associated spray nozzle or accessory.

Contact your local steel specialist if your application requires pressure ranges beyond those stated in this catalog.

NOZZLE MATERIALS

For each nozzle there is a selection of "standard" materials that have been determined to meet the usual requirements of the applications most commonly associated with that type of nozzle. Standard materials include brass, steel, various stainless steels, hardened stainless steels, many plastics and various carbides. Spray nozzles can also be supplied in other materials upon special request including:

- AMPCO® 8
- CARPENTER® 20 (Alloy 20)
- Ceramics
- CUPRO® NICKEL
- Graphite
- HASTELLOY®
- INCONEL®
- MONEL®
- Nylon
- Polypropylene, PVC and CPVC
- REFRAX®
- Silicon carbide
- Stellite®
- Titanium
- Zirconium

NOZZLE WEAR

Nozzle wear is typically characterized by an increase in nozzle capacity, followed by a general deterioration of the spray pattern. Flat fan spray nozzles with elliptical orifices experience a narrowing of the spray pattern. In other spray pattern types, the distribution within the spray pattern deteriorates without substantially changing the coverage area. The increase in nozzle capacity can sometimes be recognized by a decrease in system operating pressure, particularly when using positive displacement pumps.

Materials having harder surfaces generally provide longer wear life. The chart below provides standard abrasion resistance ratios for different materials to help you determine if you should consider a different material for your nozzles, orifice inserts and/or spray tips.

Materials that offer better corrosion resistance are also available. However, the rate of chemical corrosion on specific nozzle materials is dependent on the solution being sprayed. The corrosive properties of the liquid being sprayed, its percent concentration and temperature, as well as the corrosion resistance of the nozzle material to the chemical must all be considered.

APPROXIMATE ABRASION RESISTANCE RATIOS

Spray Nozzle Material	Resistance Ratio
Aluminum	1
Brass	1
Polypropylene	1–2
Steel	1.5–2
MONEL	2–3
Stainless Steel	4–6
HASTELLOY	4–6
Hardened Stainless Steel	10–15
Stellite	10–15
Silicon Carbide (Nitride Bonded)	90–130
Ceramics	90–200
Carbides	180–250
Synthetic Ruby or Sapphire	600–2000

See Trademark Registration and Ownership, page i-1.

MAINTAINING SPRAY NOZZLES

Like any precision component, spray nozzles wear over time. Spray nozzle wear can be hard to detect. Small changes in performance can result in quality problems and wasted water, chemicals and electricity. The cost of using worn nozzles can be very significant – tens of thousands of dollars or more per year. Detecting nozzle wear in the early stages can prevent a significant profit drain.

USING NOZZLES THAT ARE SPRAYING JUST 15% OVER THE RATED CAPACITY*

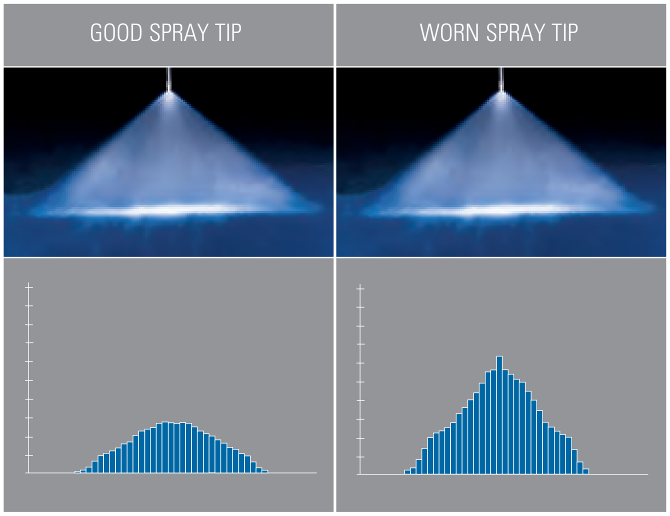
	WASTE	COST OF EXCESS
WATER	1,701,835 gallons (6,442,146 liters)	US $4,680
CHEMICALS	170,165 gallons (644,145 liters)	US $170,164
WASTEWATER DISPOSAL	1,872,000 gallons (7,086,291 liters)	US $7,956
TOTAL COST OF USING WORN NOZZLES:		**US $182,800**

*Based on total system flow of 100 gpm (379 lpm). Water cost of US $2.75/1000 gallons (3,785 liters). Chemical cost of US $1.00 per gallon ($0.264 per liter) and a dilution ratio of 10:1. System operates 2080 hours per year. Increased electricity cost, scrap and downtime due to quality problems are not included.

DETECTING WORN SPRAY NOZZLES

Visually inspecting nozzles is a start but unless wear is significant, it may not be detectable.

The graphic below illustrates this problem. The spray tip on the left is new and sprays properly. The spray tip on the right is worn and sprays 30% over capacity. The difference is undetectable by inspecting the nozzle, but spray collection data reveals the difference between the two tips.



WATCH FOR THESE SIGNS OF NOZZLE WEAR:

- **Quality control issues and increased scrap.** Check for uneven coating, cooling, drying or cleaning and changes in temperature, dust content and humidity
- **Flow rate change:**
  - For centrifugal pumps: monitor flow meter readings to detect increases or collect and measure the flow from the spray nozzle for a given period of time at a specific pressure and compare them to flow rate readings from new, unused spray nozzles
  - For positive displacement pumps: monitor the liquid line pressure for decreases; the flow rate will remain constant
- **Spray pressure in the nozzle manifold:**
  - For centrifugal pumps: monitor for increases in liquid volume sprayed. The spraying pressure is likely to remain the same
  - For positive displacement pumps: monitor pressure gauge for decreases in pressure and reduction in impact on sprayed surfaces. The liquid volume sprayed is likely to remain the same. Also, monitor for increases in pressure due to clogged spray nozzles
- **Deterioration of spray pattern quality.** Visually inspect the spray pattern for changes. Check the spray angle with a protractor. Measure the width of the spray pattern on the sprayed surface

REPLACING WORN NOZZLES

Inspecting and maintaining your nozzles on a regular basis will help identify wear and extend service life. However, wear will occur over time and the only solution is to replace your nozzles.

Here are a few guidelines to help you determine the optimal replacement interval:

- Are worn nozzles affecting product or process quality? If so, replace nozzles as soon as any wear is evident
- Is water conservation a priority? If so, replace nozzles as soon as wear is evident
- How much are you spending by continuing to use worn nozzles? How do the additional costs for water, chemicals, electricity and wastewater disposal compare with the cost of replacement nozzles?
- Is precise spray performance important to your overall process? If so, you may want to set pre-determined dates for nozzle replacement such as annual or semi-annual maintenance shutdowns

For more information on nozzle maintenance and replacement, visit spray.com. Or, contact your local steel specialist for assistance developing a nozzle maintenance program.