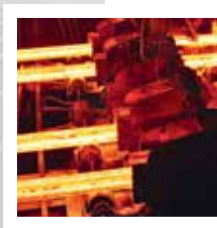
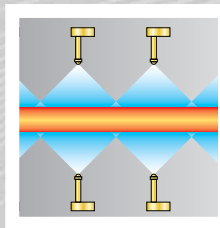
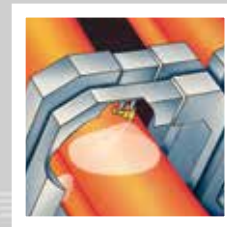
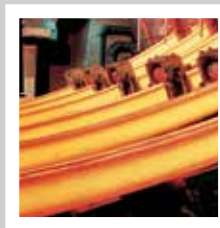


ENGINEERING  
YOUR SPRAY SOLUTION



## Precision Spray Nozzles and Solutions for Secondary Cooling



**Continuous Casting**

# LECHLER NOZZLES FOR SECONDARY COOLING IN CONTINUOUS CASTING – ECONOMICAL AND EFFICIENT

Lechler is a world leader in nozzle technology. For over 135 years, we have pioneered numerous groundbreaking developments in this field. Comprehensive nozzle engineering know-how is combined with a deep understanding of application-specific requirements to create products that offer outstanding performance and reliability.

## New challenges for the steel industry

Steel producers all over the world are feeling the pressure from new competitors due to the trend of globalization. On one hand, they are forced to reduce production costs, while on the other, they have to meet demands for new high-quality steel grades. In order to succeed in this environment, it is essential that all processes are optimized – including secondary cooling.

## Intelligent cooling

Cooling can be defined in many ways. In the complex field of iron and steel manufacturing, numerous different influencing factors have to be taken into account. Different steel grades require individual cooling processes. The same applies for different

steel formats. Separately adjusted cooling profiles are required to ensure stress-free cooling of both flat and long product casters.

## Your advantages

- Tailor-made nozzle solutions for billets, blooms and slabs
- Increased casting speed
- Higher productivity
- Extended product range (special steels)
- Longer service life and reduced maintenance costs
- Increased product quality



# THE IDEAL WAY TO OPTIMUM COOLING



## Unique range of products and solutions

The ultimate cooling solution for all requirements does not exist. Instead each process has individual demands for every installation type, every steel format and every steel grade. Due to multiple possibilities, standard solutions are usually not suitable. Therefore we analyze the specific situation of our customers in detail. When selecting the optimum nozzles for a particular application, we take into account numerous parameters such as:

- design of the installation
- new nozzle designs
- air-water ratio
- turn-down range of the nozzles
- water distribution
- measurement of the heat transfer coefficient of the nozzles
- new methods of nozzle attachment and new nozzle tube designs



## Years of experience

In view of the complexity of the task, we always take into account the overall process when developing our solutions. Our knowledge and years of experience in continuous casting form the basis for products and cooling solutions that ensure increased productivity and quality in steel production in the long term.

With subsidiaries in Hungary, USA, England, India, China, France, Belgium, Sweden, Finland, Italy and Spain, as well as qualified agents in over 40 countries, we are represented all over the globe and will also provide you with on-site support.



## Individual advice

Each customer has his own requirements and goals. That is why we take time to listen. We then clarify any open questions together, with you. When developing your custom solution, we use state-of-the-art measuring techniques in order to precisely determine liquid distribution and cooling performance. Communication with our customers is a high priority for us.

**Contact us and let us jointly define the best possible solution for future-oriented secondary cooling.**

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# NOZZLES AND SERVICES FOR CONTINUOUS CASTING PROCESSES



The main purpose of nozzles in continuous casting processes is the cooling of the strand surface. This spray water cooling is the only controllable part of the secondary cooling process and is therefore a major factor in determining maximum productivity and optimum quality of continuous casting processes.

In the secondary cooling process the spray nozzle arrangement and process parameters determine the characteristics of spray water cooling. The spray nozzle arrangement defines the area on the strand surface where spray cooling occurs. Process parameters such as operating pressures and flow rates determine the cooling intensity and distribution on the strand surface.

Heat extraction from the strand surface is a result of both, nozzle arrangement and process parameters which therefore define the cooling and solidification process. As a premium nozzle manufacturer Lechler does not only supply prime quality nozzles, systems and accessories;

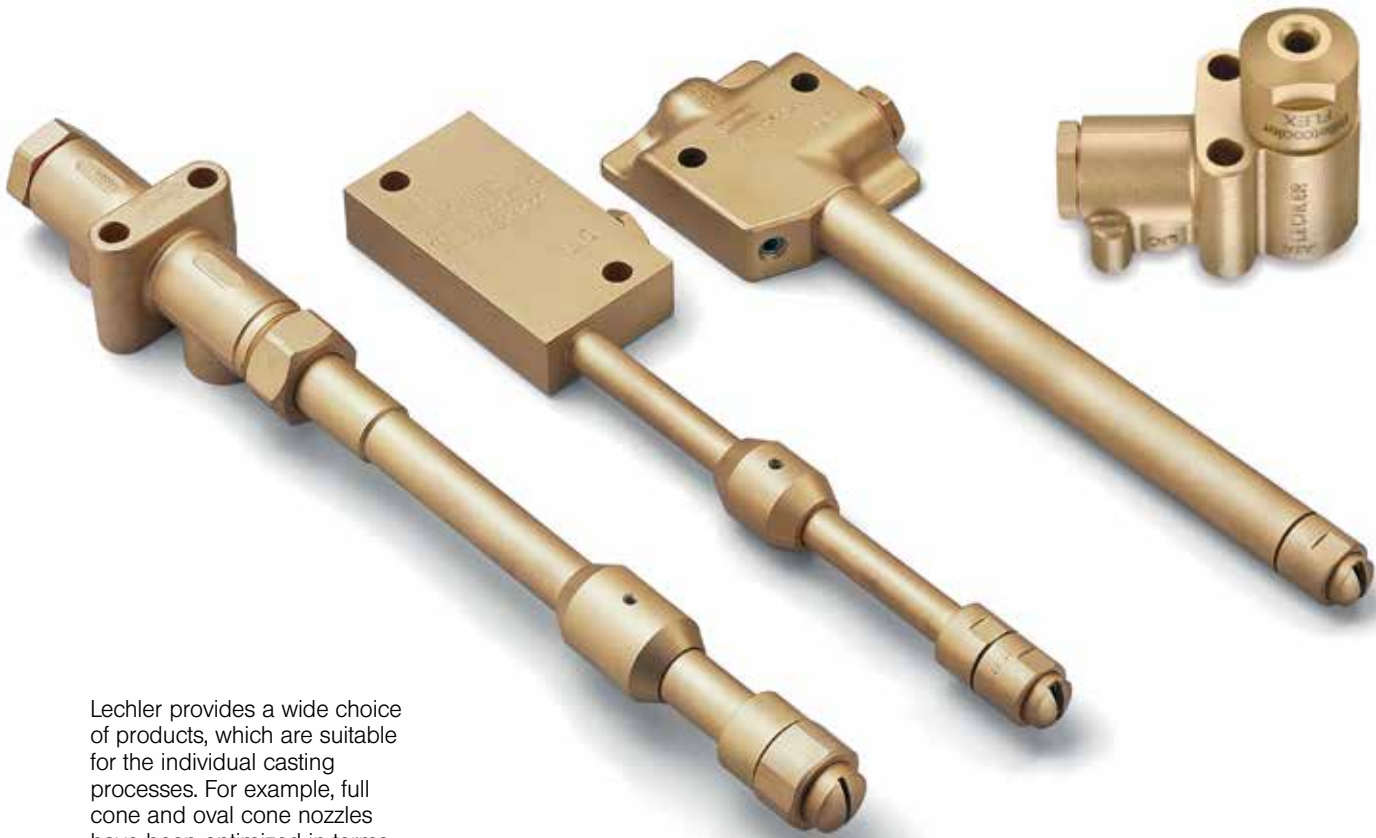
Lechler also provides **detailed engineering and measurement knowledge** and services in the areas of both nozzle arrangement and process parameter optimization.

The optimization possibilities in nozzle arrangement include nozzle alignment, header and segment pipe design and liquid distribution optimization for new and existing systems. For process parameters, optimization possibilities lie in the choice of the atomization type (air-mist or single fluid nozzle), spray kinetics, spray impact and the correlated cooling efficiency (measured surface heat transfer coefficient).

The requirements on secondary cooling of the casting processes vary with section size and steel grade. Therefore, special nozzle types are available to meet the multiple requirements and provide the optimum cooling solution for each secondary cooling system.

In addition, Lechler provides capabilities in continuous casting process simulation which can be utilized for secondary **cooling process optimization**, e.g. by optimizing the steel grade specific spray plan or **predicting the maximum casting speed** for an upgraded secondary cooling system.





Lechler provides a wide choice of products, which are suitable for the individual casting processes. For example, full cone and oval cone nozzles have been optimized in terms of liquid distribution and flow rates to meet the challenges of long product casting processes.

Special nozzle series have also been developed for long and flat product casting processes:

- **Billetcooler Series** for long product casting
- **Mastercooler Series** for flat product casting
- **Mastercooler Hard-Hard Cooling** for thin slab casting processes

- high quality nozzle technology
- long term experience in the field of secondary cooling
- caster life-cycle support
- process optimization



Secondary cooling zone of billet caster

# NOZZLE MEASUREMENT TECHNOLOGY

## Performance measurements

As a high quality nozzle manufacturer, our laboratories have developed special techniques to produce reliable data on nozzle parameters, which are critical in terms of secondary cooling. Lechler's laboratories are therefore equipped with measurement techniques to measure flow rates, liquid distribution and spray impact for all typical nozzle arrangements of continuous casting processes.

## Flow rates

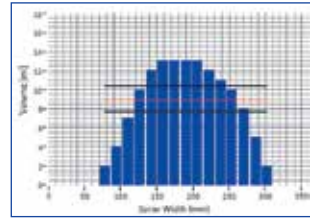
Multiple high precision facilities are available to measure pressure and flow rate of water.

## Liquid distribution

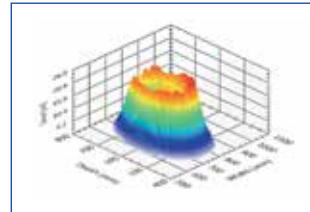
It is the spray nozzle manufacturer's task to design nozzles, providing the desired water distribution over the entire turn down ratio. In a slab caster, the uniformity of the water distribution across the entire strand surface is essential for good quality slab for all water and air operating pressures.

In billet and bloom casters also the spray water distribution needs to be controlled to avoid over- or undercooling of the strand surface. Several measurement facilities are available at Lechler for measurement of all typical secondary cooling configurations for single and multi nozzle setups with varying resolutions to match our customers' demands.

In addition to the well proven dynamic distribution measurement method, which



Example of dynamic liquid distribution measurement

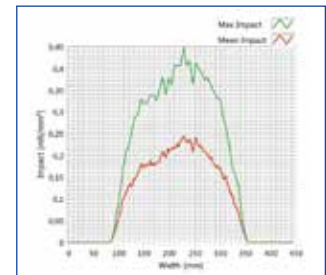


Example of 3-D liquid distribution measurement

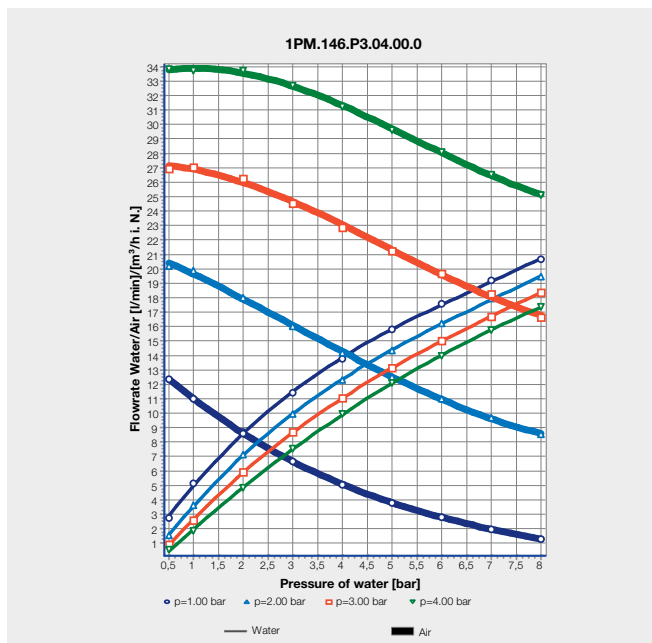
determines the total liquid distribution profile of a nozzle on the strand surface as a function of the strand width, Lechler laboratories are equipped to measure the 3-D liquid distribution profile, identifying the exact local spray density in each position of the nozzle spray.

## Spray impact

There are also additional factors influencing the cooling efficiency, such as the air-water ratio, the water turn down ratio or the spray foot print of the spray nozzles. One method to estimate the cooling efficiency is the measurement of the spray nozzle impact on the strand surface. Therefore, Lechler provides sophisticated technology to measure the local impact for each position in the nozzle spray with a high resolution even for low flow rates of secondary cooling nozzles quantifying the force applied by the spray on the surface for all defined operating conditions.



Example of low pressure impact measurement



Pressure - flow rate diagram of air-mist nozzle (Mastercooler type)



Liquid distribution measurement

- Precise pressure and flow rate measurement of varying fluids
- High definition 3-D liquid distribution measurement
- Dynamic liquid distribution measurement for multi-nozzle layouts
- High definition pressure impact measurement

# HEAT TRANSFER IN SECONDARY COOLING AND HTC MEASUREMENT

Since the main task of spray nozzles in continuous casting is cooling, the most important characteristic of a spray nozzle is the cooling efficiency, which is often quantified by the heat transfer coefficient (HTC).

The heat transfer between nozzle spray and high temperature surfaces is a complex mechanism and results in many factors such as:

- surface condition (temperature, material, scale formation, roughness)
- spray kinetics on surface
  - water distribution and density (spray height, spray angles, flow rates)
  - local droplet size and speed (flow rates, pressures, spray height, nozzle type, spray angles, spray direction, interference between sprays)
- spray water temperature

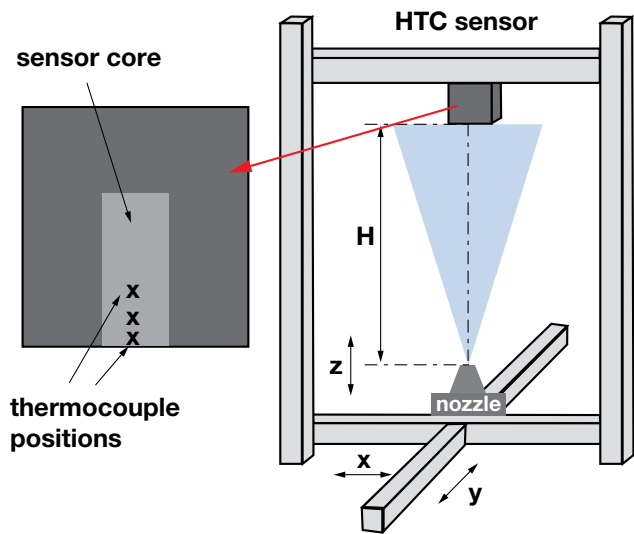
For example the effect of the surface temperature on the HTC is shown for 2 different spray intensities in the picture. The effect of the surface temperature is reduced for

high temperatures due to the Leidenfrost effect. Therefore many models assume a constant heat transfer above Leidenfrost, which mainly varies as a function of the spray water density.

Several approaches exist to characterize the heat transfer as a function of all these parameters. However, the most accurate way is the actual testing of the cooling efficiency either on a caster or in a laboratory.

Lechler has a history of experience in investigations of the cooling efficiency, resulting from long term cooperation with multiple national and international research centers, OEMs and steel plants.

In cooperation with various institutes and universities, Lechler has carried out extensive heat transfer tests with varying nozzle types and varying testing procedures. One of the tested methods for HTC measurement consists of a sensor, which is measuring the local temperature drop in the spray. The sensor scheme

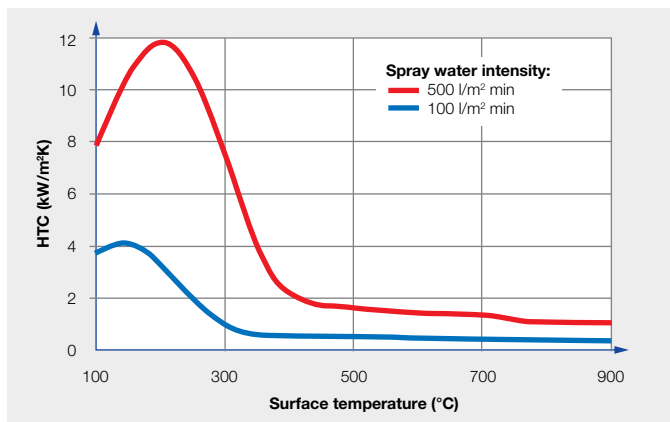


Scheme of HTC measurement method

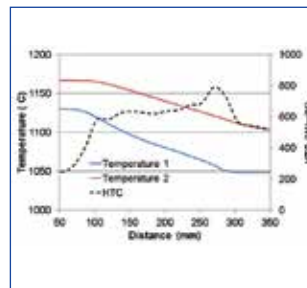
shown in the picture illustrates this basic principle. As a result the local HTC can be calculated for constant nozzle operation (flow rates, pressures, spray height) and boundary conditions of the sensor (initial temperature, casting speed) based on the temperature profile of the sensor as shown in the picture below. These calculated HTC values can be used to predict the general cooling efficiency of the nozzle. A correlation of the water distribution profile for the same conditions with

the calculated HTC values gives a complete picture of the interaction between spray water density, spray kinetics (e.g. defined by pressures, spray height and impact angle) surface temperature and HTC.

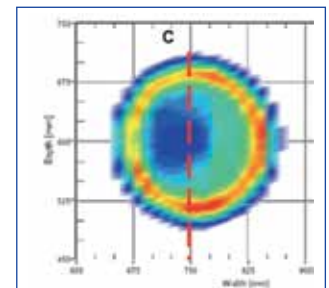
Lechler can provide assistance in characterising the nozzles cooling efficiency, either based on the long experience in nozzle technology and continuous casting processes or based on experiments in cooperation with our partners from research and industry.



Effect of surface temperature and spray intensity on HTC



Measured temperatures and calculated local HTC (left) and spray water distribution profile with indicated measurement positions (right)



# Single fluid vs. air-mist nozzle technology

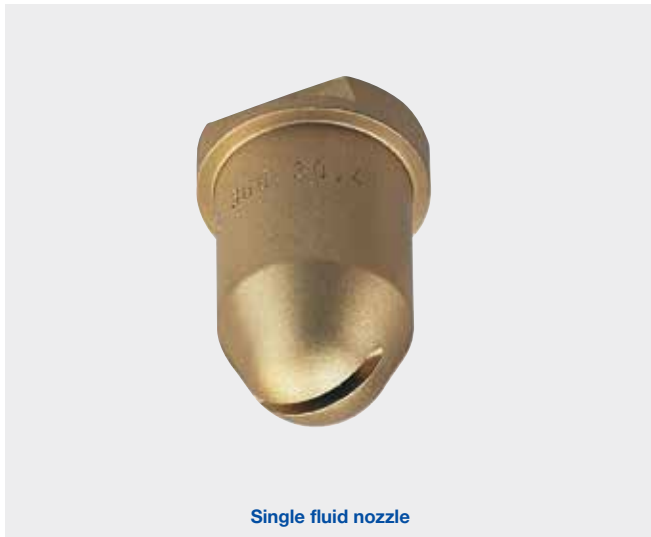
The initial secondary cooling systems for continuous casting machines have utilized single fluid spray nozzles. From these first methods the nozzle technology has been improved, although many machines are still running on water only achieving high productivity and high quality. However, most modern continuous casting machines require high flexibility in terms of steel grade and section size variation. Since this high flexibility is also required

from the secondary cooling system, most of these casters are equipped with air-mist nozzles.

The main advantage of Lechler air mist nozzles compared to single fluid nozzles is an increased water turndown ratio. The water turn down ratio is calculated from the flow rate at maximum operating water pressure (typically 101 psi) divided by the flow rate at minimum operating

water pressure (typically 7.3 psi for air-mist nozzles and 14.5 psi for single fluid nozzles). Within these operating pressures, the nozzles show a stable spray water distribution. Typical air-mist nozzles show water turndown ratios from 10-30 while the ratio of single fluid nozzles is typically limited to 2.6-3.7. This increased ratio provides a higher flexibility in terms of heat transfer variation.

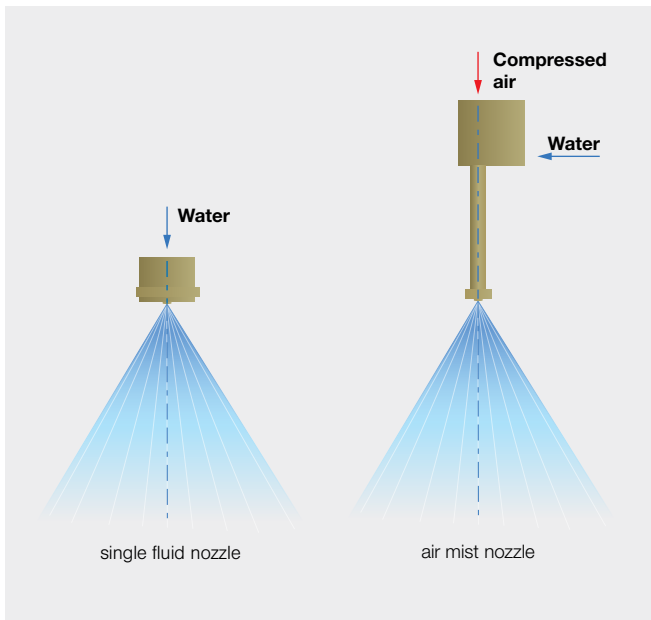
Since air mist nozzles operate with compressed air in addition to water, the required free cross sections to provide the same water flow rate are increased compared to single fluid nozzles. The increased free cross sections are less prone to internal nozzle clogging caused e.g. by poor spray water quality and as a result show increased nozzle lifetime and reduced maintenance workload.



Single fluid nozzle



Air-mist nozzle



single fluid nozzle

air mist nozzle

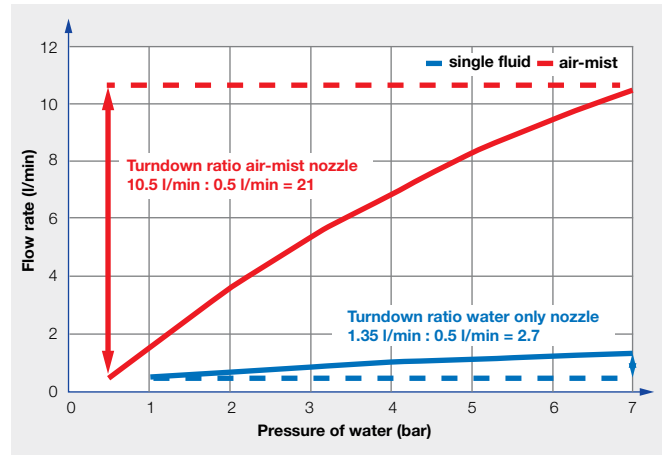
Single fluid Cooling	Air mist Cooling
Water flow turndown ratio ~3.7 : 1 maximum.	Water flow turndown ratio ~30 : 1 maximum
small cross sections	large cross sections
Clogging tendency increased	Clogging tendency is minimised
Major spray angle varies with water pressure	Constant spray angles
uneven liquid distribution	even liquid distribution
Heat extraction capability is limited	Higher heat extraction capabilities
Limited casting speed range for ideal solidification conditions	Provides a wide casting speed range for ideal solidification conditions
Can restrict the range of steel grades which can be cast on one casting machine	Permits a wide range of steel grades to be cast on one casting machine
Requires larger water flows than air-mist, less costly installation	Requires less water flows than water only, more costly installation



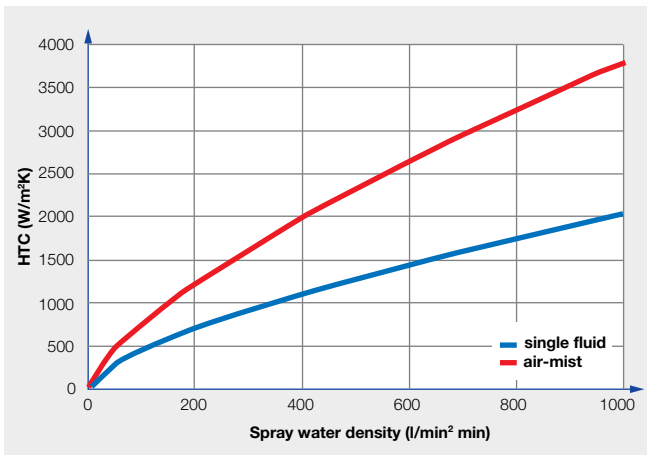


Due to the spray kinetic energy resulting from the interaction between water and air the spray angle of an air mist nozzle is generally more stable with varying water pressure compared to single fluid nozzles. This also results in a more even liquid distribution of the spray water on the strand surface. Air-mist nozzles for slab casting machines are especially designed to provide an even liquid water distribution to the strand surface for all specified operating conditions.

Comparison of air-mist (top) and single fluid nozzle (bottom) tip geometry for same nozzle size



Comparison of turn down ratio single fluid vs air-mist nozzle



Comparison of HTC of single fluid vs air-mist nozzle

Many of Lechler's air mist spray nozzles used for secondary cooling benefit from an increased spray kinetic energy, which results in an increased heat extraction, compared to single fluid nozzles with the same spray water intensity. This increased heat transfer coefficient allows the same heat to be extracted from the strand with a reduced amount of spray water. Also the effect of the spray water temperature on the heat transfer coefficient is reduced with air mist nozzles.

**As a result of these benefits, air mist nozzles are most suitable for continuous casting machines, which require a high casting speed range, and a wide range of steel grades with multiple section sizes.**

# CONTINUOUS CASTING STUDIES

## Lechler provides detailed engineering knowledge of the continuous casting process and the secondary cooling system.

The secondary cooling system is an area of key technology and its modification can greatly contribute to increased production, quality and flexibility.

A caster secondary cooling audit is a systematic and structured approach to determine how an existing secondary cooling system, operational practices and process automation data, impact quality and productivity.

The scope of an audit can vary by simply increasing nozzle capacities to a complete redesign of a secondary cooling system.

### Secondary Cooling Audit

- Benchmarking existing conditions
- Diagnosing problems
- Providing solutions
- Proposal and plan on how to implement process, operational and maintenance improvements so that the required objectives are achieved

### Setting the Objectives for a Revamp

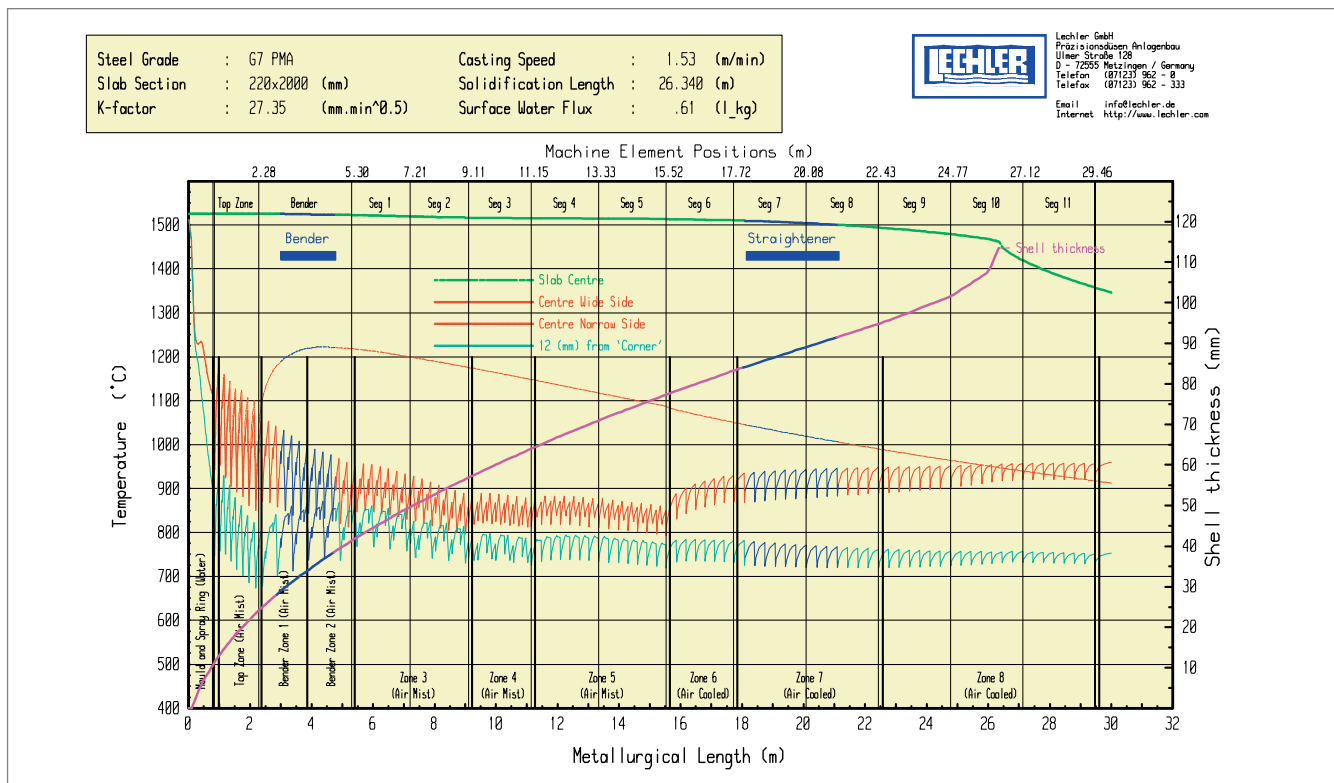
- Identify product quality defects and how to eliminate them
- Improve ease of maintenance and reduce costs
- Maximize production by increasing casting speeds
- Change of strand formats and steel grades (product mix)

### Typical Audit procedure

- Benchmarking of Existing Conditions
- Diagnosing Problems
- On Site Plant Survey
- Off Site Analysis
- Conclusive Report

### Providing Solutions

- Conclusions on existing casting conditions
- Secondary cooling layout, nozzle layout and capacities
- Maximum and minimum flow rates
- Required changes in supply pipe work
- Control instrumentation
- Secondary cooling control and control data
- Conclusions and recommendations on operational and maintenance practices

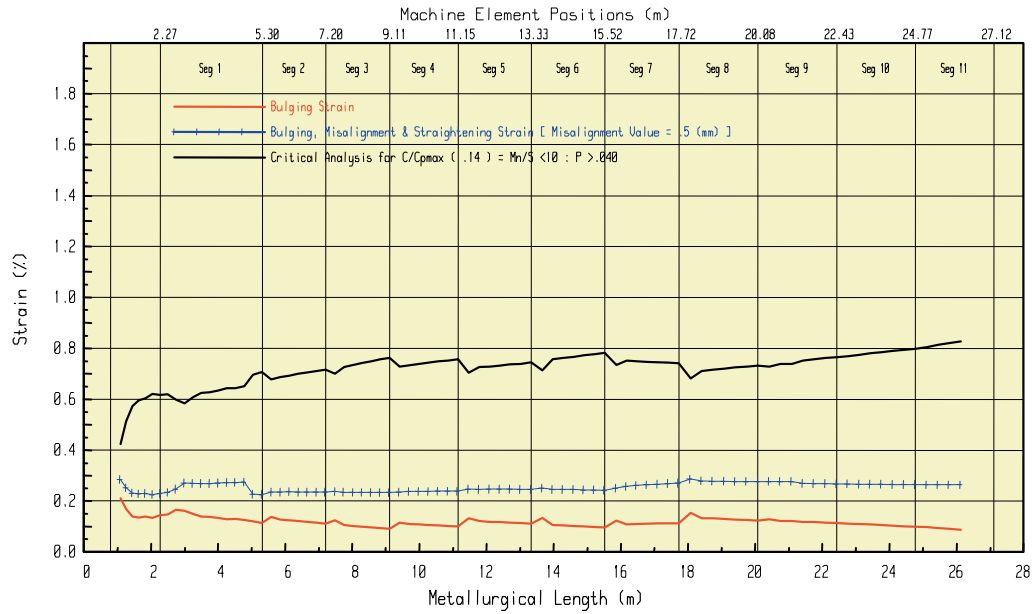


Typical temperature and solidification profile

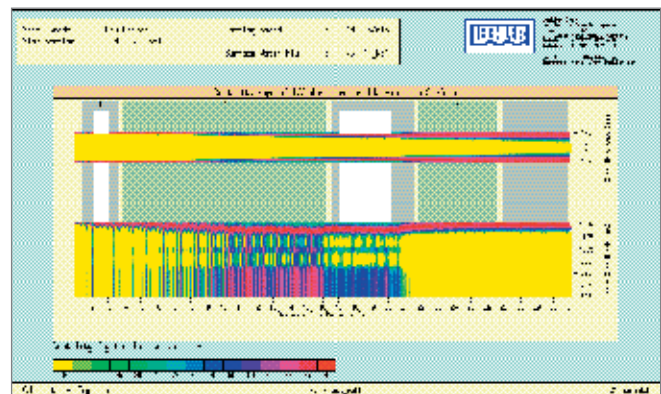
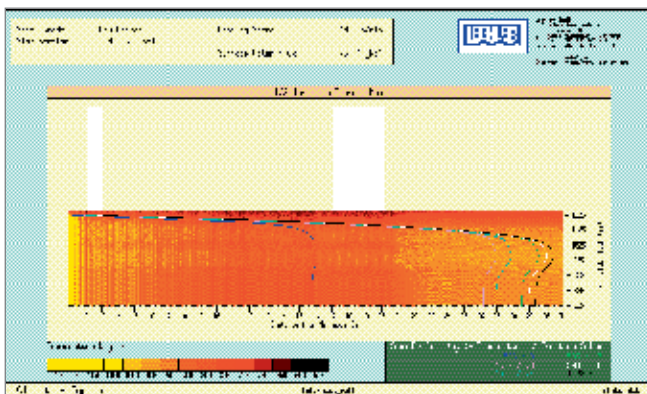
Steel Grade	: 67 PMA	Casting Speed	: 1.53 (m/min)
Slab Section	: 220x2000 (mm)	Solidification Length	: 26.340 (m)
K-factor	: 27.35 (mm.min <sup>0.5</sup> )	Surface Water Flux	: .61 (l/kg)



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 Internet http://www.lechler.com



Typical strain profile



Typical surface temperature, centre line solidification profile (left) and surface ductility profile (right)

# REASONS FOR NOZZLE REPLACEMENT

## Introduction

As with other manufacturing tools, proper maintenance of spray nozzles components cannot be ignored, since there are many factors that will affect their level of performance over time. Experience tells us that nozzles require regular inspection and maintenance and sometimes replacement in order to maintain final product quality and production processes on a cost-efficient basis. In the early stages of deteriorating performance, the overall effect may be hardly noticeable. It can be difficult to discover the source of the problem unless you know what to look for. In addition to causing the waste of electrical energy, water, chemicals, and other materials, poor nozzle spray performance can also directly affect the quality of the final product.

Caster performance can be affected significantly with regard to strand surface quality and productivity by damaged, worn or clogged spray nozzles.

Here are the basic problems which can occur when the nozzles used are not well-suited to the application, improperly installed or assembled or not properly maintained. But keep in mind that spray nozzles are not designed to last forever, which makes routine nozzles maintenance even more important.

## Erosion/wear

Degrading metal from the nozzle orifice and internal flow passages will become larger and/or distorted. Flow is usually increased, pressure may be decreased, spray pattern becomes irregular, and the spray drops become larger.

## Corrosion

Breakdown of the nozzle material due to the chemical action of sprayed material or environment. Effect is similar to that caused by erosion and wear, with possible additional damage to the outside surfaces of the nozzle.

## Caking

Build-up of material on the inside or outer edges of the orifice, caused by evaporation of the liquid. This leaves a layer of dried solids and obstructs the orifice or internal flow passages.

## Clogging

Unwanted solid particles blocking the inside of the orifice, restricting the flow and disturbing spray pattern uniformity.



Clogged vane of a full cone nozzle

## Improper assembly

Some nozzles require careful re-assembly after cleaning, so that internal components, such as gaskets, o-rings, and internal valves are properly aligned. Improper positioning may cause leakage, as well as inefficient spray performance. Overtightening of nozzle caps onto bodies can cause thread stripping.

## Accidental damage

Damage to an orifice or nozzle by inadvertent scratching or mishandling during installation or operation. Also, smaller orifices can be severely damaged by use of improper tools during cleaning.

## Flow rate increase

In all nozzles, the flow rate will increase as the surfaces of the orifice and/or internal vane or core begin to deteriorate. Possible harm to the product or process quality can also result.

In applications using positive displacement pumps, which provide the same capacity regardless of pressure, the spraying pressure will decrease as the nozzle orifice enlarges because of wear or corrosion. This is effecting the turn down ratio of an air mist nozzle.

## Spray pattern quality

The pattern of flat fan sprays deteriorates by developing streaks and heavier flows in the center of the pattern, accompanied by a decrease in the effective spray angle coverage. In coating applications, these non-uniform spray patterns can seriously affect the application results of the finished product quality.



Mechanically worn retaining nut caused by roller contact. Nozzle extension pipe was not supported and aligned

# MAINTENANCE

## How to detect nozzle problems

### Flow rate

With centrifugal pumps, nozzle flow rates usually increase at a given pressure when the orifice continues to wear. Since this increased flow will not be visually noticeable, periodic flow rate checks are suggested. These checks can be done by monitoring flow meter readings, or by collecting and measuring the spray from the nozzle for a given period of time at a specific pressure. These readings can then be compared to the flow rate listed in catalog calculations or compared to the flow readings from new, unused nozzles. When using positive displacement pumps, orifice wear is accompanied by a drop in the liquid line pressure while the flow rate remains constant.

### Spray pattern

Visual inspection can easily reveal changes in the uniformity of flat spray patterns which are caused by orifice damage, clogging or caking. However, in cases where the orifice is wearing gradually, changes in spray patterns may not be detected until after the flow has increased substantially. In applications requiring accurate uniformity of spray coverage, special equipment or tests are required to check pattern uniformity.

### Nozzle alignment

When using several flat spray nozzles on a manifold to provide an overall uniform coverage on a strand passing under the sprays, it is very important that all nozzles be oriented correctly in relation to each other. Therefore, all the flat spray patterns should be aligned to ensure accurate coverage. All patterns should also be parallel to each other.

## Consider alternatives with your present spray system

Reduce the quantity of abrasive particles or concentration of corrosive chemicals. While these changes cannot be made in most applications, possible reductions in the amount of abrasive particles in the feed liquid, and changes in the size and shapes of the particles may reduce the wear effects. If corrosion is a problem, the corrosive activity of a solution can occasionally be reduced by using different concentrations and/or temperatures, depending on the specific chemicals involved.

In many applications, orifice deterioration and clogging is caused by solid dirt particles in the sprayed liquid. In spraying systems involving continuous water recirculation, it's possible for water to be contaminated with dirt and debris which can cause orifice clogging and/or orifice wear. To minimize this type of nozzle problem, line strainers or nozzles with built-in strainers are recommended with a screen mesh size chosen to trap larger particles that may clog the nozzle orifice or vane.

## Prevent damage to the orifice during the cleaning process

As part of a standard nozzle maintenance and inspection procedure, nozzle orifices should be cleaned regularly and carefully, using cleaning probes made of materials much softer than the nozzle orifice surface. Otherwise, the critical orifice shape or size can be permanently damaged, thereby resulting in distorted spray patterns and/or increased capacity.

Bristle brushes or wooden and plastic probes can be used, while wire brushes, pocket knives or welders'

tip cleaning rasps should be avoided. In some stubborn clogging problems, it is suggested to soak the clogged orifice in a non-corrosive cleaning chemical to soften or dissolve the clogging substance.

Also cleaning in an ultrasonic bath with a weak acid can dissolve clogging substances.

## Air and water filtration

Lechler recommends to maintain the following air and water quality by means of applying the appropriate utilities.

## AirMist Cooling Air Supply

### Dewpoint

37°F

### Cleanliness

99.9% removal of 5 micron particles

99.5% removal of 1 micron particles

### Oil free

The air pressure shall be controlled at 29 psi constant

## Spray Cooling Water Quality

The water presented to the machine is required to be equal to or better than the following conditions:

Suspended Solids	20 ppm
Particle Size	0.2 mm
Total Salt Content	3000 ppm
Sulphate (SO4)	500 ppm
Chloride (Cl)	250 ppm
Silica (as SiO2)	150 ppm
Carbonate Hardness (CaCO3)	300 ppm
Total Hardness (CaCO3)	1000 ppm
pH	6 to 9.5
Free Oil	5 ppm
Dissolved Oil	10 ppm



Air mist nozzle after break out of liquid steel

# BILLETCOOLER FLEX

With today's standard diameters of up to 40 in., bloom casters place significantly higher demands on cooling compared to smaller formats.

New steel grades and increasing format sizes are significantly more susceptible to cracking, they demand more homogeneous cooling with reduced water flow rates.

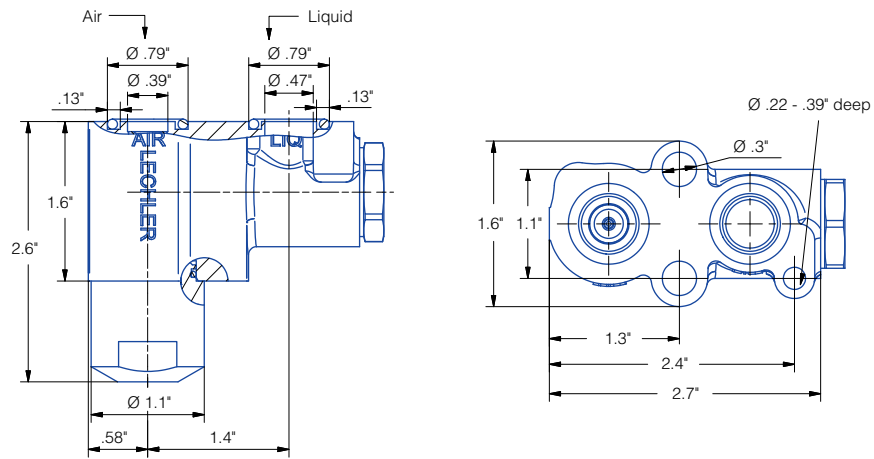
Secondary cooling in continuous casting machines for long products, normally consists of several cooling zones. The nozzle arrangement is usually defined for a specific format range. In order to permit casting of different steel grades under these conditions, the nozzles themselves must have a wide operating window.

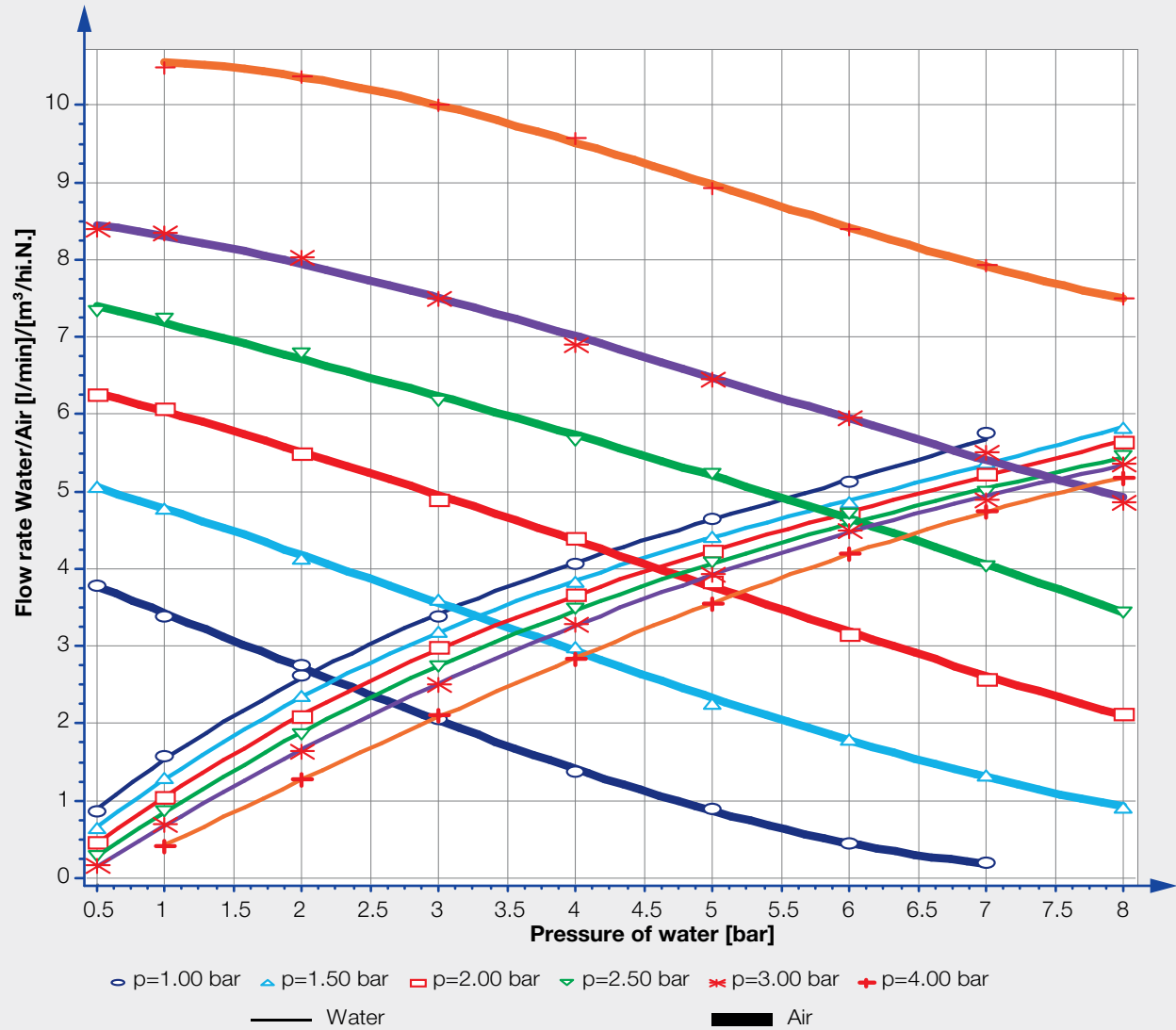
Conventional air mist nozzles quickly reach their limits here. The degree of cooling is determined above all by the flow rate of the cooling water, which is adjusted by means of the water pressure. In the past, however, the spray geometry usually also changed with the water pressure.

A modified spray angle led to a change in the liquid distribution which results in non-uniform cooling.

On newer bloom formats with larger cross sections can result in surface stresses and even cracks in the finished product.

Our goal was therefore to develop a nozzle that guarantees a stable spray angle over the entire turn-down ratio, thereby ensuring optimum cooling.





Typical pressure-flow rate diagram of a **Billetcooler FLEX**® nozzle. The large turn-down ratio of 1:10 (0.5 to 5 l/min) can be clearly seen in the lower curves for water.

The diagram on this page demonstrates the flexibility of the new **Billetcooler FLEX®**. As an example, the selected nozzle size shows the adjustable liquid distributions as a function of the flow rates with indication of the respective air pressures.

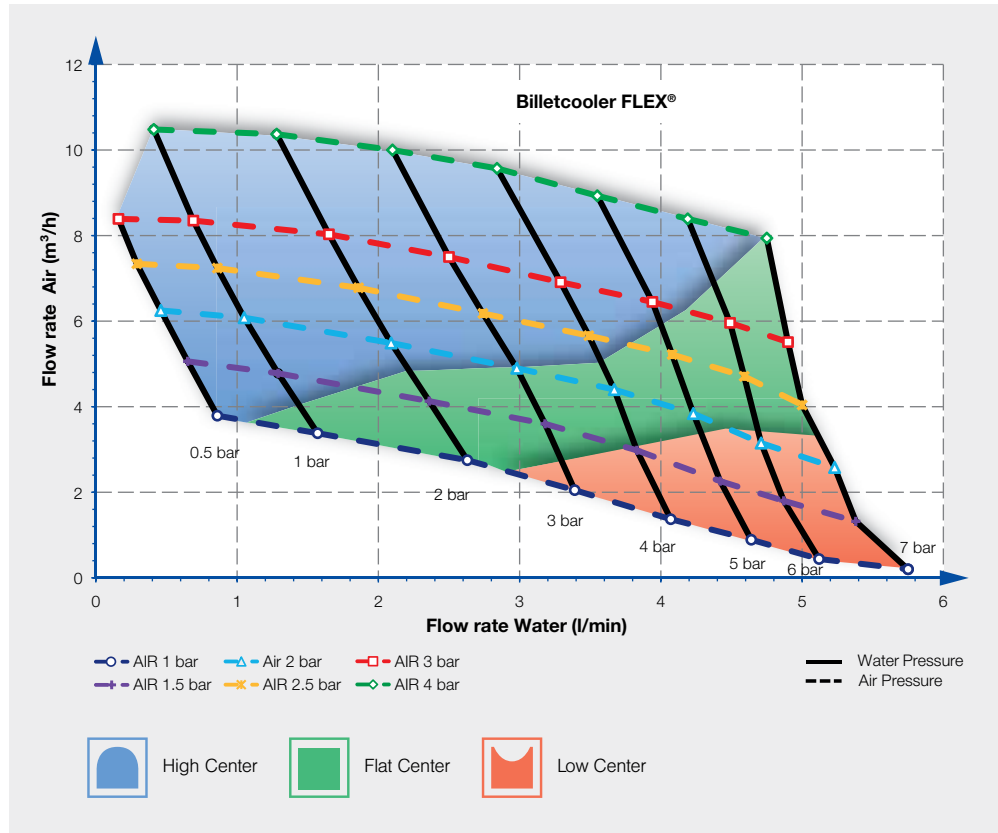
The liquid distribution can be controlled by the correct selection of the air pressures for comparable water flow rates. As described on the previous page, this allows the local cooling to be adapted to the process-specific requirements.

From the diagram, it is possible to see how a large operating range can be covered with varying air and water supply pressures.

The colored areas represent the different spray characteristics of the nozzle.

In the blue area, the liquid distribution is concentrated and decreases towards the edge of the spray.

The green area is characterized by homogeneous liquid distribution, while the spray characteristic in the red area is similar to a hollow cone nozzle with ring-shaped distribution.



Typical flow distribution chart of a **Billetcooler FLEX®**



# Flexible water flow rate – stable spray angle

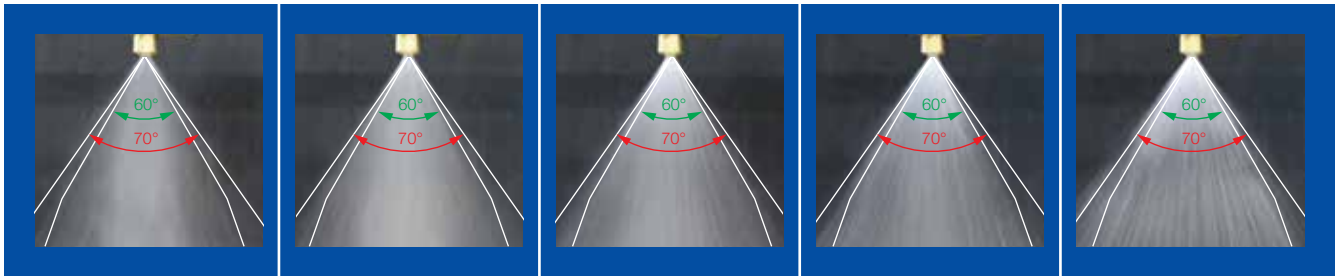
The new **Billetcooler FLEX®** nozzle is characterized by its constant spray angle over the entire turn-down range.

We offer three different nozzle sizes, each with a turn-down ratio (min./max. water flow rate) of 1:10.

Lechler therefore covers the requirements of most bloom and billet casters with just three standard nozzles.

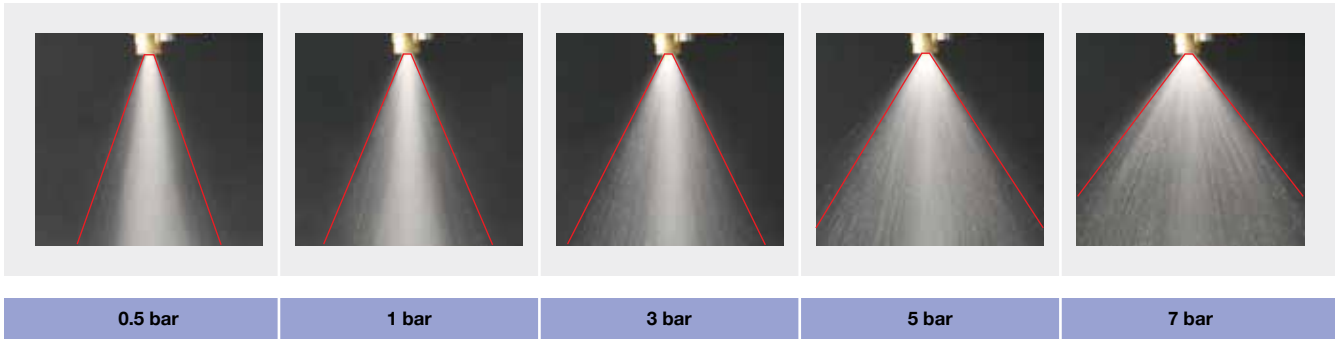
This minimizes the number of different nozzles, reduces logistics costs and helps to avoid maintenance mistakes.

## BILLETCOOLER FLEX




Typical example for 60° version

### Conventional nozzle



At varying water pressures and with a constant air pressure of 2 bar, the spray coverage of the **Billetcooler FLEX®** (top row) is much more homogeneous than with conventional nozzles (bottom row).

## Technical specifications

Spray angle 	Type	Nozzle size	Min. water flow rate [l/min]	Max. water flow rate [l/min]	Narrowest free cross-section [mm]		Material		Weight
					Water	Air	Nozzle	Gasket	
45°	<b>1PM.150.30.33</b>	<b>0.80</b>	0.3	3.0	1.40	1.40	Brass	Viton	0.9 kg
	<b>1PM.150.30.35</b>	<b>1.25</b>	0.5	5.0	1.90	1.90	Brass	Viton	0.9 kg
	<b>1PM.150.30.38</b>	<b>2.00</b>	0.8	8.0	2.15	2.15	Brass	Viton	0.9 kg
60°	<b>1PM.150.30.03</b>	<b>0.80</b>	0.3	3.0	1.35	1.35	Brass	Viton	0.9 kg
	<b>1PM.150.30.05</b>	<b>1.25</b>	0.5	5.0	1.90	1.90	Brass	Viton	0.9 kg
	<b>1PM.150.30.08</b>	<b>2.00</b>	0.8	8.0	2.20	2.15	Brass	Viton	0.9 kg

# BILLETCOOLER FLEX® – advantages and benefits

## Stable spray angle

The **Billetcooler FLEX®** is characterized by its constant spray angle over the entire turn-down range.

➡ **No strand overcooling or undercooling**

## Flexible cooling

With **Billetcooler FLEX®**, the water distribution can be individually adjusted for different formats.

➡ **Optimum cooling guaranteed at all times**

## Large free cross-sections

Clog-resistant and maintenance-friendly, thanks to very large free cross-sections for air and water.

➡ **High operating reliability**

## New design

All nozzle variants of the **Billetcooler FLEX®** have a forged, space- and weight-saving nozzle body.

➡ **Maintenance-friendly design**

## Lower air consumption

Thanks to the new nozzle design, the **Billetcooler FLEX®** requires less compressed air than basic air mist nozzle designs and therefore helps to improve the energy efficiency of the overall installation.

➡ **Reduces operating costs**

## Low noise emissions

Compared with conventional nozzles for secondary cooling, the **Billetcooler FLEX®** reduces noise emissions by up to 15 dB.

➡ **Improved work safety**



# Billetcooler Oval Spray

## BilletCooler air mist nozzles

With this type of nozzle, it is possible to utilize air mist cooling in billet and bloom casters very effectively. The compact block design allows mounting either on horizontal spray rings as well as on vertical nozzle headers. A turn down ratio as wide as 1 : 10 is standard at water pressures between 7.3 and 102 psi at 29 psi constant air pressure, provides a wide range of cooling intensities.

The oval cone spray footprint provides the option to cool a larger area of the strand with one nozzle spray only, which increases the cooling efficiency. Various angles for spray width and spray depth are available to compensate for different spray heights, which meet the requirements of the individual machine types. Large free passages compared to hydraulic and competitor air-mist nozzles result in reducing nozzle clogging. Billetcooler oval cone nozzles cover a flow rate range from .11 to 3.28 gpm.

### The benefits

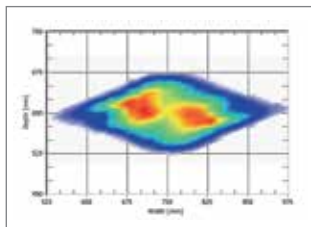
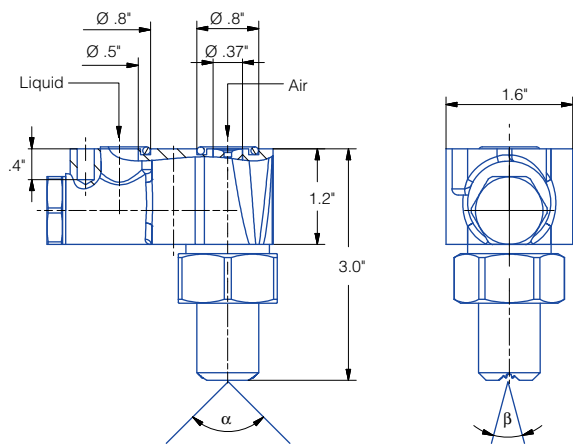
- High turn-down ratio (min./max. flow rate) 10:1 (max. 14:1) for high flexibility and extended product (steel grade) mix, reduces the number of different nozzle types in the machine
- Compressed air consumption reduced by appr. 40% for lowering operation costs



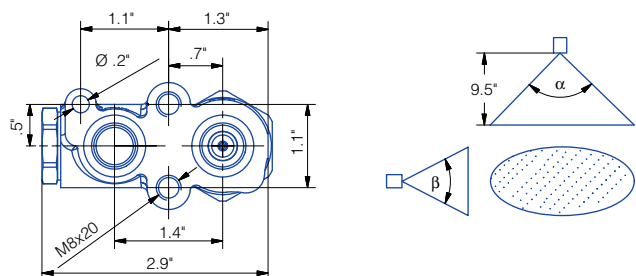
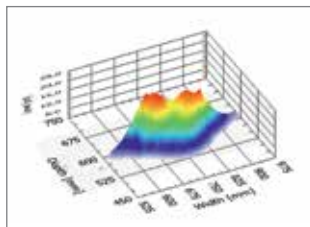
Nozzle type	Max. water flow rate	Operating water pressure	Max. air flow rate	Operating air pressure	Spray angle
<b>Billetcooler oval</b>	3.54 gpm	7.3 – 102 psi	7 SCFM	14.5 – 58 psi	60/90° (wide) 30/45° (deep)

Benchmark data only, individual nozzle data to be specified

- High Heat Transfer Coefficient (HTC) for high casting speeds
- Compact design ideal for spray rings and vertical headers
- Plate connection for easy and maintenance friendly mounting
- Large free passages prevent clogging for high operation safety with improved plant availability
- Successfully installed in most long product air-mist cooling systems worldwide
- Reduced maintenance costs



Liquid distribution Billetcooler Oval



# Billetcooler Cone Spray

## BilletCooler air mist nozzles

With this type of nozzle it is possible to utilize air mist cooling in **billet** and **bloom** casters for **rounds** very effectively. The compact block design allows mounting either on horizontal spray rings as well as on vertical nozzle headers. A turn down ratio as wide as 1 : 10 is standard at water pressures between 7.3 and 102 psi at 29 psi constant air pressure provides a wide range of cooling intensities.

The cone spray footprint distributes the liquid closer towards the edges; avoiding overcooling of the area beneath the nozzle position. The characteristic is often utilized with round product casters. Various angles are available to compensate for different spray heights, and meet the requirements of the individual machine types. Large free passages compared to hydraulic and competitor air-mist nozzles result in reducing nozzle clogging tendency. Billetcooler cone spray nozzles cover a flow rate range from .11 to 2.1 gpm.

### The benefits

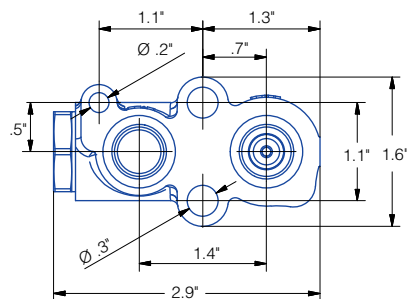
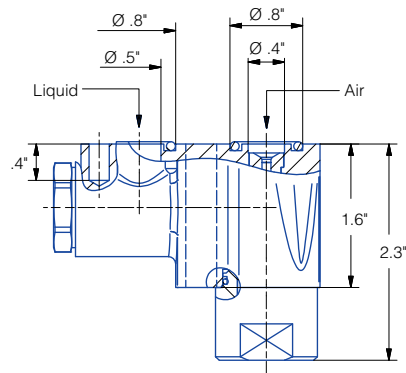
- High turn-down ratio (min./max. flow rate) 10:1 (max. 14:1) for high flexibility and extended product (steel grade) mix, reduces the number of different nozzle types in the machine
- Compressed air consumption reduced by appr. 40% for lowering operation costs
- High Heat Transfer Coefficient (HTC) for high casting speeds



Nozzle type	Max. water flow rate	Operating water pressure	Max. air flow rate	Operating air pressure	Spray angle
<b>Billetcooler cone spray</b>	2.1 gpm	7.3 – 102 psi	5 SCFM	14.5 – 58 psi	45°/60°/90°

Benchmark data only, individual nozzle data to be specified

- Compact design ideal for spray rings and vertical headers
- Plate connection for easy and maintenance friendly mounting
- Large free passages prevent clogging for high operation safety with improved plant availability
- Successfully installed in most long product air-mist cooling systems worldwide
- Reduced maintenance costs



# Billetcooler Special Flat Gasket and Filter Inserts

## Special Flat Gasket

The entire air mist nozzles for secondary cooling in billet and bloom casters can be exposed to high temperatures, unlike slab casters, because of the close mounting proximity to the strand. A special gasket should be used in combination with the Billetcooler nozzles if longer periods without any secondary cooling spray water do not occur. In this case, the high temperature resistant special flat gasket replaces the standard Viton O-Rings.

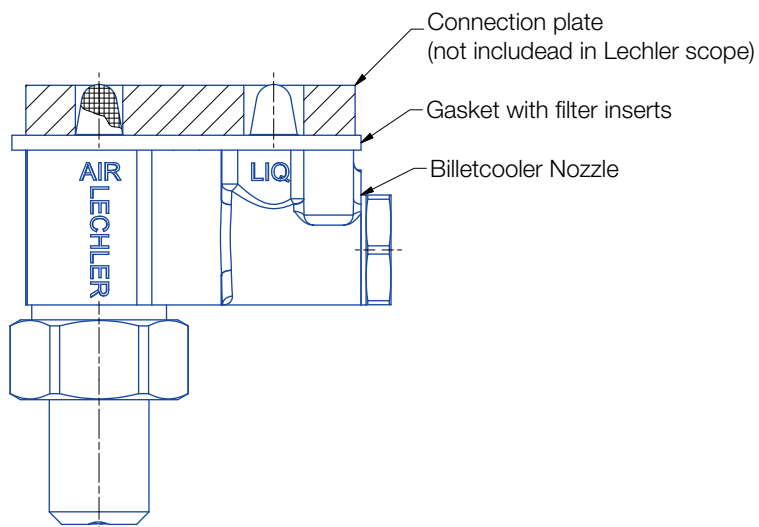
## Filter inserts for water and compressed air

The identical filter inserts have been designed for the use in combination with the special flat gasket only. The filters protect the Billetcooler inside and the nozzle tip from clogging. Solid particles being carried into the nozzle, by either polluted cooling water or compressed air, will be kept away. Nevertheless, a sufficient filtration of both fluids is still essential for a trouble free cooling operation with good product quality.



Item	Ordering no.	Material	Mesh size
<b>Gasket only</b>	1PM.021.L1.20.09.0	Novaphit SSTC	-
<b>Gasket with 2 filter inserts</b>	1PM.021.L1.20.80.0	Novaphit SSTC/304 L	-
<b>Filter only</b>	095.016.1D.15.46.0	304 L	280 Micron (55 Mesh)

Gasket and filters suitable for all standard Billetcooler nozzle types



# MASTERCooler SMART

## The air mist nozzle for every slab caster

The Mastercooler SMART is the state of the art flat fan air mist nozzle type; combining high cooling efficiency with high flexibility in terms of water turn down ratio, spray angle, nozzle arrangement and connection methods. Mastercooler SMART nozzles cover a flow rate range from .08 to 18.5 gpm.

They are equipped with a plate that is bolted vertically onto adaptor plates. Small diameter fluid feed pipes are no longer necessary. All nozzles are mounted outside of the framework at the rear side of the segment, with only the nozzle pipe carrying the spray tip reaching down to the spray position. A very rigid header pipe and a nozzle self alignment is the result.

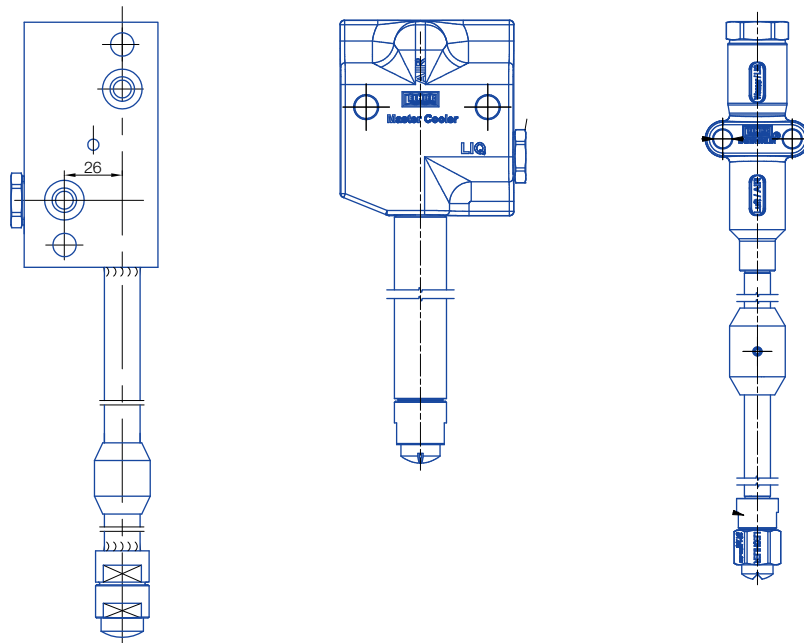


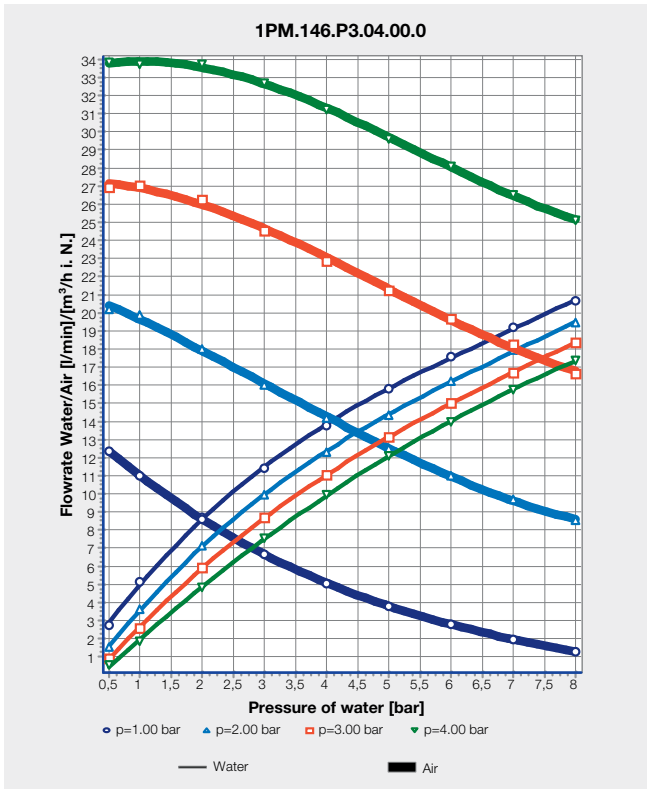
Mastercooler SMART technology is available for all slab casting machine types as the design can be adapted to match the individual requirements in terms of nozzle geometry and connection design. Nozzle parameters, such as water and air flow rates, spray angle, extension pipe length and connection plate details are customized to the requirements of each individual project.

The nozzles are fine tuned to match the spray height and nozzle pitch in each segment to provide an even liquid distribution for the whole slab width in all nozzle operating conditions. Multi nozzle measurements in the Lechler laboratories ensure the highest quality for each individually designed Mastercooler SMART nozzle type.

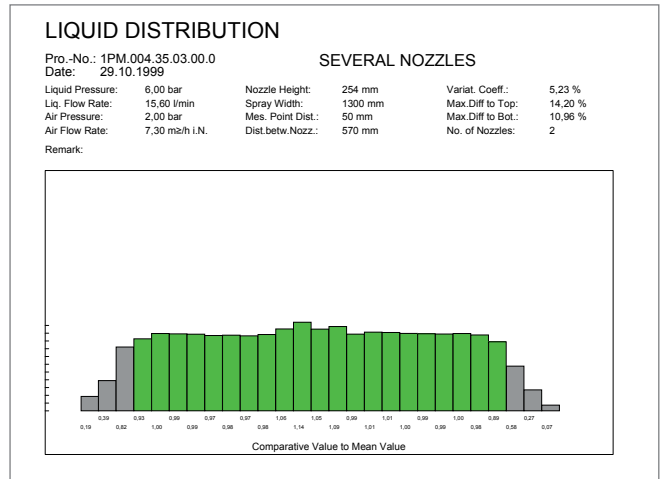
Nozzle type	Max. water flow rate	Operating water pressure	Max. air flow rates	Operating air pressure	Spray angle
<b>Mastercooler SMART</b>	18.5 gpm	73 – 145 psi	41 SCFM	14.5 – 58 psi	30 – 130°

Benchmark data only, individual nozzle data to be specified

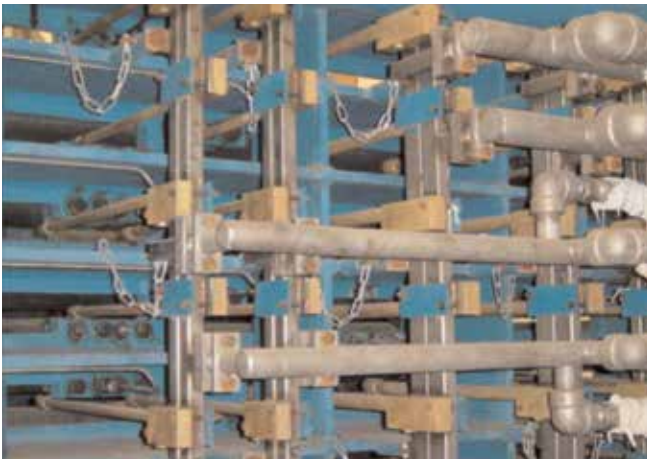




Typical Mastercooler SMART pressure-flow diagram



Typical twin nozzle arrangement liquid distribution measurement documentation



Slab caster segment with Mastercooler SMART nozzles



Horizontal segments with Mastercooler SMART nozzles

# MASTERCooler HARD HARD COOLING®

## Hard Hard® Cooling

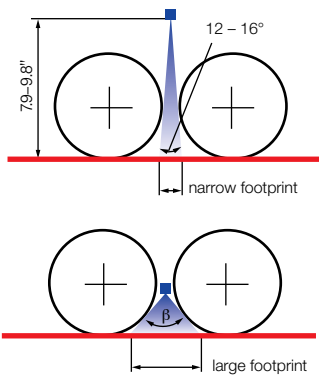
The ability to cast low carbon steels at ever increasing casting speeds, while still being able to cast the more critical steel grades, requires a wider control and performance of the secondary cooling as well as flexibility in nozzle turndown. Maintaining slab bulging at increased casting speeds requires both reduced roll pitches and increased secondary cooling intensities. The result can lead to unacceptable temperature fluctuation on the slab surface with standard secondary cooling design. Mastercooler HHC nozzles cover a flow rate range from .48 to 18.5 gpm.

One technology which provides a solution for problems is "Hard-Hard" cooling, which is the ability to apply large amounts of spray water to the slab surface in the upper cooling zones, which reduces the slab surface to below 1292°F while maintaining acceptable surface temperature fluctuations. This practice requires a special nozzle design and arrangement in the top zone of a slab caster.

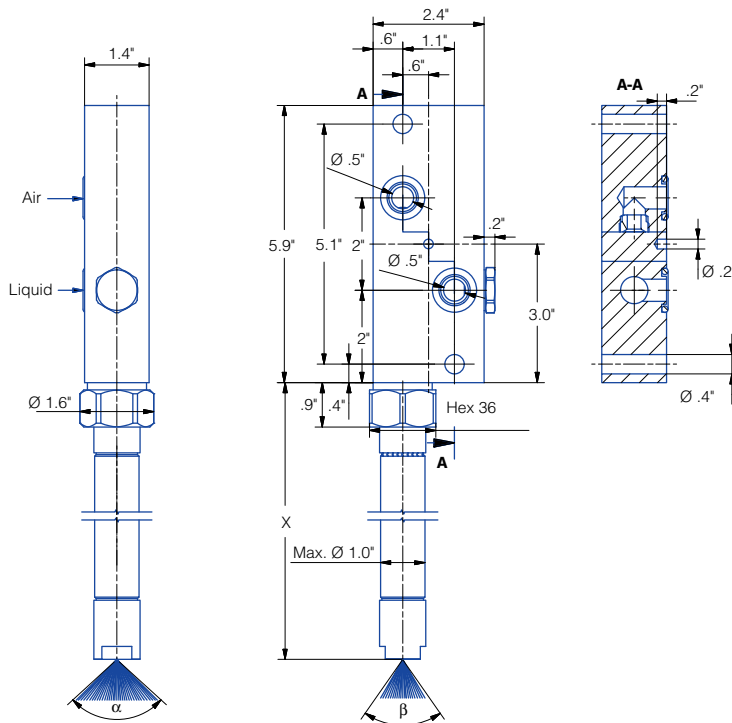


Nozzle type	Max. water flow rate	Operating water pressure	Air flow rates	Operating air Pressure	Spray angle
<b>Mastercooler HHC</b>	13 gpm	73 – 145 psi	0 – 26 SCFM	14.5 – 58 psi	90-125° wide 20-75° deep

Benchmark data only, individual nozzle data to be specified



Spray footprint for conventional air mist nozzle (top) and HHC nozzle (lower)





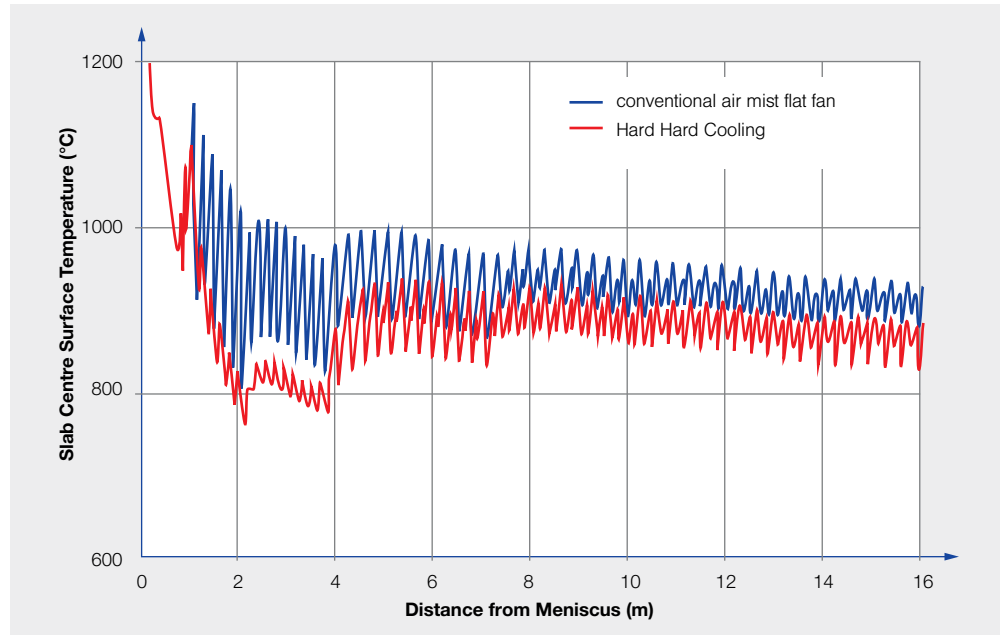
The minor spray angle of conventional nozzles, also referred to as the spray thickness angle, range between 12° and 16° for typical major spray angles of 60° to 120° (wide axis). With spray heights of 6.3" to 11.8" in the upper cooling zones, the slab surface between roll contact and spray water remains uncooled and high temperature fluctuations within the roll gap can occur.

Slab defects attributed by secondary cooling, can be minimized or avoided by reducing these surface temperature fluctuations. "Hard-Hard" cooling is a technology developed to address this issue as well as inter roll slab bulging.

"Hard-Hard" cooling technology also requires that the strand surface temperature be reduced quickly to be approximately 1292°F or less in the first cooling zone after the mold sprays. This temperature is then maintained throughout the complete solidification length of the strand.

The necessary temperature profile requires high cooling intensities through high water flows. When these water flows are applied through normal flat fan nozzles, large cyclic temperature fluctuations occur on the slab surface.

These cyclic fluctuations in the upper cooling zones of the caster can result in significant thermal stresses in the cast strand, which could lead to generating both internal and surface defects.



Intense cooling profile conventional flat fan air mist vs "Hard-Hard" cooling nozzles

Reducing the surface temperature fluctuations to acceptable levels, while still extracting the necessary heat from the slab surface, requires that the spray thickness in the casting direction is maximized within the roll gap. This is achieved with a new Lechler design concept – "Hard-Hard" cooling nozzle.

The main difference with respect to surface temperature between the conventional flat fan nozzles and the new "Hard-Hard" concept is shown by the reduction of the surface temperature fluctuations in zone 1. The "Hard-Hard" cooling nozzles also require less spray water to achieve the required cooling due to their increased minor spray angle, which produces a larger spray thickness on the slab surface.

With the low surface temperatures associated with "Hard-Hard" cooling, the loss of cooling due to clogged nozzles will result in large localized slab surface reheats. These reheats will produce large localized thermal stresses and possible defects. "Hard-Hard" cooling air mist nozzles benefit from a non-clogging nozzle tip, featuring a single slot principle, giving users the benefits of both the highest operational safety and lower maintenance.

**Hard-Hard cooling nozzles are mounted utilizing the proven Lechler MasterCooler SMART method which has become an industry standard.**



HHC nozzle tip

Hard Hard Cooling means improved slab quality and higher productivity due to:

- Lower strand temperatures in upper part of machine
- Minimized strand bulging and mould level instability
- Reduced temperature fluctuations on slab surface
- Increased quality and productivity
- Fitted Nozzle tip in roll gap
- Standard Mastercooler SMART mounting method

# Slab caster segment piping

## Mastercooler SMART Mounting

Because of their internal mixture, air mist nozzles require two separate feed pipes for compressed air and water. Vertical segment piping with square air and water main header pipes became an industry standard design. The air mist nozzles, now equipped with plates, are bolted vertically onto adaptor plates.

In order to maintain an identical nozzle length in one segment, the nozzles are bolted onto adaptor plates of a tailored length to compensate for the in-built bending radius.



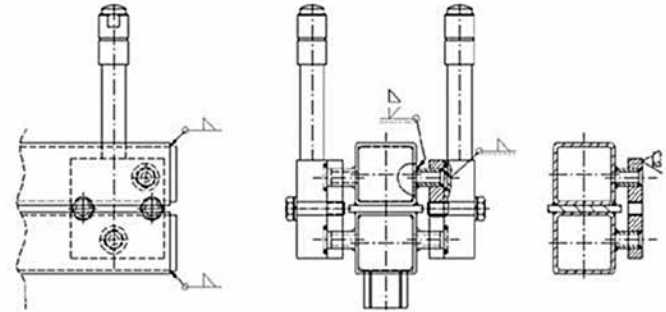
Air mist nozzles fed and installed by means of small and long hydraulic pipes

Nozzle staggering between the roller gaps within one segment can be served from only one header pipe manifold. Nozzle staggering is one method to equalize the water distribution along the strand in the direction of the length with the intention to eliminate surface defects and cracks.

Small diameter fluid feed pipes are no longer necessary. All nozzles are mounted outside of the framework at the rear side of the segment with only the nozzle pipe, carrying the spray tip, reaching down to the spray position. A very rigid header pipe with self alignment nozzle arrangement is the result. The nozzle spray position is always secured. A "Hoseless" fluid supply system is possible.

In order to maintain an identical nozzle length in one segment, the nozzles are bolted onto adaptor plates of a tailored length to compensate for the in-built bending radius.

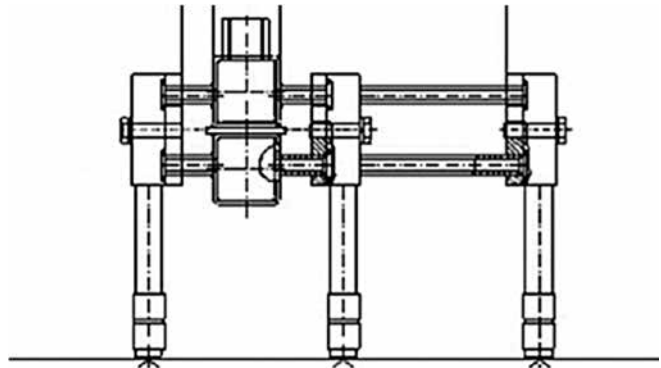
Nozzle staggering between the roller gaps within one segment becomes much easier, since different nozzle positions can be served from only one header pipe manifold. Nozzle staggering is one method to equalize the water distribution along the strand in the direction of the length with the intention to eliminate surface defects and cracks.



Air mist nozzle with vertical plate connection and square pipe header manifold



Air mist nozzle with vertical plate connection and adaptor plate



Nozzle staggering



Example of staggered nozzle positions with Mastercooler SMART piping

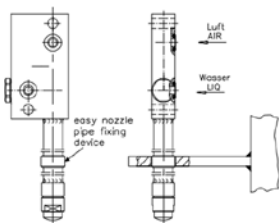
# Split pipe design and tip alignment

## Nozzle and tip alignment

Lechler nozzle tips are equipped with two standard fixed keys which ensures the correct position of the spray tip providing the correct spray direction and plane. However, there are cases where the tip adapter on the extension pipe of the nozzle has four holes, so that the nozzle tip can be turned by 90° for versatility reasons. For this reason, the correct nozzle tip spray direction has to be checked and ensured during assembly of the nozzles and headers.

## Nozzle and pipe alignment

An additional tool for nozzle alignment is a bushing, which is flexibly or permanently mounted on the nozzle pipe. This bushing is a counterpart for a welded plate on the segment, which keeps the nozzle pipe in position to avoid pipe misalignment.



Nozzle alignment with bushing

## Nozzle Body Interface

It is important that the nozzle body mounting surface is kept clean and free of marks in order to secure a tight connection. Please make sure that new o-rings are being used whenever the nozzle is removed for a major repair or off-site maintenance. It is also important that the plugs be kept tight with undamaged copper seals.

## Split pipe design

For nozzles with extension pipes longer than approximately 11.8" it is recommended to install nozzles with the "Split Pipe" version, allowing to the front part to separate, carrying the nozzle tip and nut only. The nozzle's vertical plate combined with the remaining part of pipe can be retained. The position of the joint between the two pipe ends can be designed on request. A self-aligning design also secures the correct spray direction at this point. In case of a break out, only the extension pipe with the tip has to be replaced.



Mastercooler nozzle body mounting surface with air and water inlet holes including o-rings, air and water plugs including copper seals

### The special features:

- Only extension pipe needs to be replaced after a break out
- Very rigid and durable connection
- Failure proof system due to a variety of the different joint shapes

### The benefits:

- Lower maintenance costs
- Improved operation safety
- Reduced complexity of stock logistics due to reduced number of nozzle types for beam-blank casters



Mastercooler split pipe design

# Flat fan nozzle with dovetail alignment Series 660

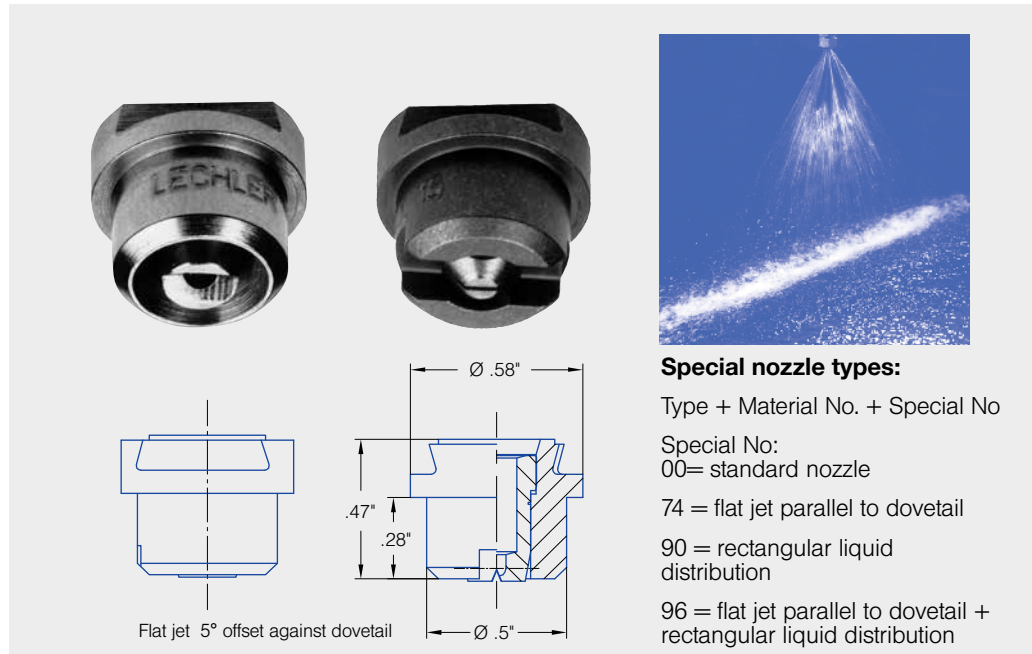
## Series 660

Assembly with retaining nut. Self-aligning jet with dovetail design secures correct spray position for optimal strand surface quality and easy maintenance. Standard version with parabolic liquid distribution.

### Applications:

Multi nozzle arrangements for strand cooling in foot roller area of slab casters where space is limited.  
Multi nozzle arrangements in segments for water only secondary cooling in stainless steel slab casters with low water flow rates.

- Standard offset angle 5° built into the nozzle
- 0° offset angle available on request 660.xxx.xx.74



### Special nozzle types:

Type + Material No. + Special No


Special No:  
00= standard nozzle

74 = flat jet parallel to dovetail

90 = rectangular liquid distribution

96 = flat jet parallel to dovetail + rectangular liquid distribution

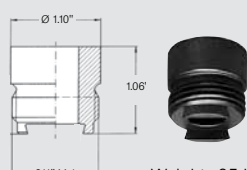
Spray angle	Ordering no.				Equivalent Orifice diam. (in.)	Free passage (in.)	Flow Rate (Gallons Per Minute)						Spray Coverage @ 30 psi		
	Type	Material no.					psi	psi	liters per minute 10 bar	20 psi	2 psi	40 psi	60 psi	80 H=10"	100 H=20"
		303 SS 16	316 SS 17 <sup>1</sup>	Brass 30											
20°	660.301	○	○	○	.028	.024	.05	.07	.32	.10	.12	.14	.16	2	4
	660.361	○	○	○	.039	.032	.10	.14	.63	.20	.24	.28	.31	3	5
	660.441	○	○	○	.053	.043	.19	.27	1.3	.39	.48	.55	.61	3	5
	660.481	○	○	○	.059	.047	.25	.35	1.6	.50	.61	.70	.78	3	5
30°	660.302	○	○	○	.024	.020	.05	.07	.32	.10	.12	.14	.16	4	8
	660.362	○	○	○	.039	.028	.10	.14	.63	.20	.24	.28	.31	4	8
	660.402	○	○	○	.047	.035	.16	.22	1.0	.31	.38	.44	.49	4	8
	660.482	○	○	○	.059	.043	.25	.35	1.6	.50	.61	.70	.78	4	8
	660.562	○	○	○	.079	.059	.39	.55	2.5	.78	.95	1.1	1.2	4	8
45°	660.303	○	○	○	.028	.020	.05	.07	.32	.10	.12	.14	.16	7	13
	660.363	○	○	○	.039	.024	.10	.14	.63	.20	.24	.28	.31	7	13
	660.403	○	○	○	.047	.035	.16	.22	1.0	.31	.38	.44	.49	7	13
	660.483	○	○	○	.059	.043	.25	.35	1.6	.50	.61	.70	.78	7	13
	660.563	○	○	○	.079	.055	.39	.55	2.5	.78	.95	1.1	1.2	7	14
	660.643	○	○	○	.099	.071	.62	.88	4.0	1.2	1.5	1.8	2.0	7	14
60°	660.304	○	○	○	.028	.016	.05	.07	.32	.10	.12	.14	.16	11	21
	660.334	○	○	○	.035	.020	.07	.10	.45	.14	.17	.20	.22	11	21
	660.364	○	○	○	.039	.024	.10	.14	.63	.20	.24	.28	.31	11	21
	660.404	○	○	○	.047	.032	.16	.22	1.0	.31	.38	.44	.49	11	21
	660.444	○	○	○	.053	.035	.19	.27	1.3	.39	.48	.55	.61	11	21
	660.484	○	○	○	.059	.039	.25	.35	1.6	.50	.61	.70	.78	11	21
	660.514	○	○	○	.065	.043	.29	.42	1.9	.59	.72	.83	.93	11	21
	660.564	○	○	○	.079	.051	.39	.55	2.5	.78	.95	1.1	1.2	11	21
	660.604	○	○	○	.087	.059	.49	.69	3.2	.98	1.2	1.4	1.5	11	21
	660.644	○	○	○	.099	.063	.62	.88	4.0	1.2	1.5	1.8	2.0	11	21
	660.724	○	○	○	.118	.083	.98	1.4	6.3	2.0	2.4	2.8	3.1	11	20
660.804	-	○	○	.158	.102	1.6	2.2	10.0	3.1	3.8	4.4	4.9	11	20	
75°	660.145	○	-	○	.008	.005	.01	.01	.05	.02	.02	.02	.02	13	24
	660.165	○	-	○	.008	.003	.01	.01	.07	.02	.03	.03	.03	13	24
	660.185	○	-	○	.008	.006	.01	.02	.09	.02	.03	.03	.04	13	25
	660.215	○	-	○	.020	.008	.02	.02	.11	.03	.04	.05	.05	13	25
	660.245	○	-	○	.020	.300	.02	.03	.16	.05	.06	.07	.08	14	25
	660.275	○	-	○	.024	.300	.03	.05	.22	.07	.08	.10	.11	14	25

Spray angle 	Ordering no.			Equivalent Orifice diam. (in.)	Free passage (in.)	Flow Rate (Gallons Per Minute)							Spray Coverage @ 30 psi		
	Type	Material no.				10 psi	20 psi	liters per minute 2 bar	40 psi	60 psi	80 psi	100 psi	H=10"	H=20"	
		303 SS 16	316 SS 17												Brass 30
90°	660.216	○	-	○	.016	.200	.017	.024	.11	.034	.042	.048	.054	20	35
	660.276	○	-	○	.024	.300	.034	.05	.22	.07	.08	.10	.11	20	35
	660.306	○	○	○	.028	.016	.05	.07	.32	.10	.12	.14	.16	20	37
	660.336	○	○	○	.035	.020	.07	.10	.45	.14	.17	.20	.22	20	37
	660.366	○	○	○	.039	.020	.10	.14	.63	.20	.24	.28	.31	20	37
	660.406	○	○	○	.047	.028	.16	.22	1.0	.31	.38	.44	.49	20	37
	660.446	○	○	○	.053	.032	.19	.27	1.3	.39	.48	.55	.61	20	36
	660.486	○	○	○	.059	.032	.25	.35	1.6	.50	.61	.70	.78	20	36
	660.516	○	○	○	.065	.035	.29	.42	1.9	.59	.72	.83	.93	20	36
	660.566	○	○	○	.079	.043	.39	.55	2.5	.78	.95	1.1	1.2	20	36
	660.606	○	○	○	.087	.047	.49	.69	3.2	.98	1.2	1.4	1.5	20	36
	660.646	○	○	○	.099	.051	.62	.88	4.0	1.2	1.5	1.8	2.0	20	36
	660.676	○	○	○	.106	.055	.74	1.0	4.8	1.5	1.8	2.1	2.3	19	36
	660.726	○	○	○	.118	.067	.98	1.4	6.3	2.0	2.4	2.8	3.1	19	35
660.806	○	○	○	.158	.095	1.6	2.2	10.0	3.1	3.8	4.4	4.9	19	34	
120°	660.187	○	-	○	.014	.008	.012	.018	.08	.025	.030	.035	.039	26	48
	660.217	○	-	○	.016	.008	.017	.024	.11	.034	.042	.048	.054	26	48
	660.247	○	-	○	.020	.008	.025	.035	.16	.05	.06	.07	.08	26	49
	660.277	○	-	○	.024	.012	.034	.05	.22	.07	.08	.10	.11	26	49
	660.307	○	-	○	.028	.012	.05	.07	.32	.10	.12	.14	.16	26	50
	660.337	○	○	○	.035	.016	.07	.10	.45	.14	.17	.20	.22	26	50
	660.367	○	○	○	.039	.016	.10	.14	.63	.20	.24	.28	.31	26	50
	660.407	○	○	○	.047	.024	.16	.22	1.0	.31	.38	.44	.49	26	50
	660.447	○	○	○	.053	.024	.19	.27	1.3	.39	.48	.55	.61	26	50
	660.487	○	○	○	.059	.024	.25	.35	1.6	.50	.61	.70	.78	27	50
	660.517	○	○	○	.065	.035	.29	.42	1.9	.59	.72	.83	.93	27	50
	660.567	○	○	○	.079	.035	.39	.55	2.5	.78	.95	1.1	1.2	27	50
	660.607	○	○	○	.087	.043	.49	.69	3.2	.98	1.2	1.4	1.5	27	51
	660.647	○	○	○	.099	.051	.62	.88	4.0	1.2	1.5	1.8	2.0	28	51
660.727	○	○	○	.118	.063	.99	1.4	6.4	2.0	2.4	2.8	3.1	29	52	
660.807	○	-	○	.158	.079	1.6	2.2	10.0	3.1	3.8	4.4	4.9	31	53	

**Example** Type + Material no. = Ordering no.  
**for ordering:** 660.306 + 16 = 660.306.16

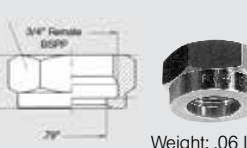
1) We reserve the right to deliver material 316 SS or 316L SS, if we show the material code 17.

### Accessories



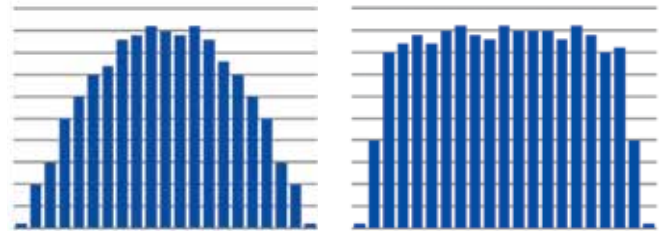
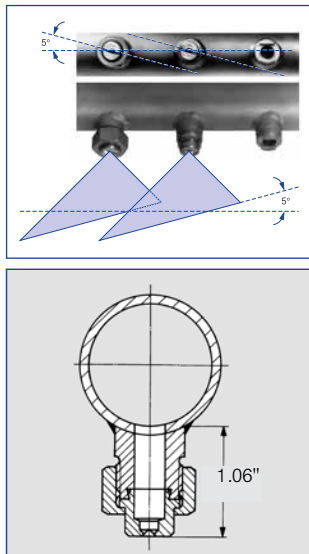
Weight: .05 lb.

Nipple **066.011.17** (316 SS)



Weight: .06 lb.

Retaining nut **065.200.16** (303 SS)  
**065.200.17** (316 SS)  
**065.200.30** (Brass)



Standard spray water distribution (left) and rectangular spray water distribution (right)

Available with

- Rectangular liquid distribution for single nozzle arrangement (per roller gap) or wide pitches 660.xxx.xx.90.
- Rectangular liquid distribution combined with 0° offset angle for single nozzle arrangement (per roller gap) or wide pitches 660.xxx.xx.96 in narrow roller gaps.

Conversion formula for the above series:  $V_2 = V_1 \sqrt{\frac{P_2}{P_1}}$

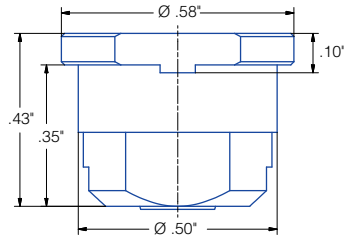
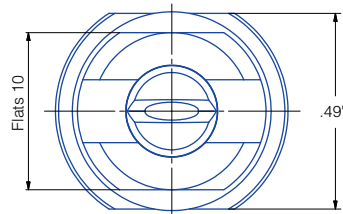
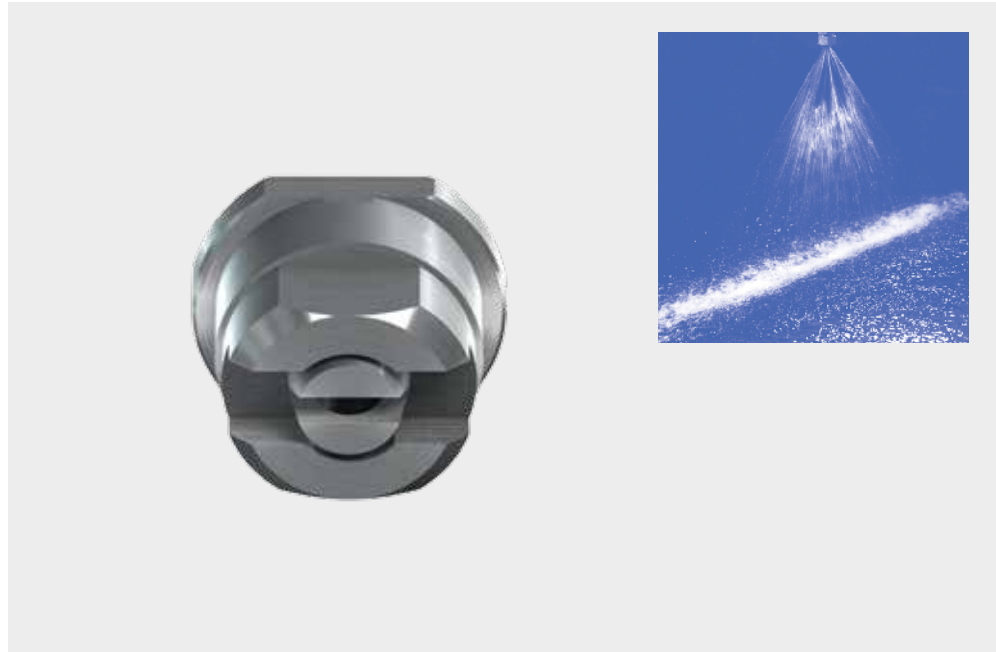
# Flat fan nozzle with double-flat alignment Series 6M2

## Series 6M2

Assembly with retaining nut. Self aligning jet with double-flat design secures correct spray position for optimal strand surface quality and easy maintenance. Standard version with parabolic liquid distribution.

### Applications:


Multi-nozzle arrangements for strand cooling in foot roller area of slab casters where space is limited. Multi-nozzle arrangements in segments for water only secondary cooling in stainless steel slab casters with low water flow rates.



Spray angle	Ordering no.				Equivalent Orifice diam. (in.)	Free passage (in.)	Flow Rate (Gallons Per Minute)						
	Type	Mat. no.					73 psi	14.5 psi	29 psi	40 psi	43.5 psi	72.5 psi	145 psi
		AISI 303	AISI 316TI	AISI 316L									
45°	<b>6M2. 403</b>	16	17 <sup>1</sup>	30	.05	.35	.13	.19	.26	.31	.32	.42	.59
	<b>6M2. 483</b>	○	○	○	.06	.04	.21	.30	.42	.5	.52	.67	.95
	<b>6M2. 563</b>	○	○	○	.08	.06	.33	.47	.66	.78	.81	1.04	1.48
	<b>6M2. 643</b>	○	○	○	.10	.07	.53	0.75	1.06	1.24	1.29	1.67	2.36
	<b>6M2. 723</b>	○	○	○	.12	.09	.83	1.18	1.66	1.95	2.04	2.63	3.72
	<b>6M2. 763</b>	○	○	○	.14	.10	1.06	1.50	2.11	2.48	2.59	3.34	4.73
	<b>6M2. 803</b>	○	○	○	.16	.12	1.32	1.87	2.64	3.1	3.24	4.18	5.91

<sup>1</sup>We reserve the right to deliver AISI 316TI or AISI 316L under the material no. 17.

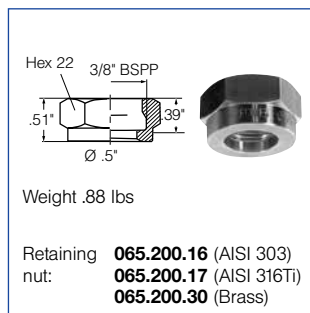
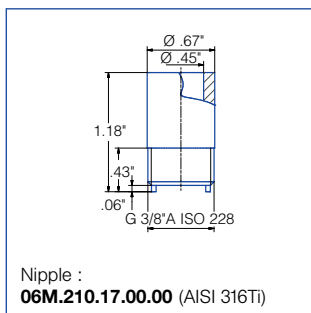
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Spray angle 	Ordering no.				Equivalent Orifice diam. (in.)	Free passage (in.)	Flow Rate (Gallons Per Minute)						
	Type	Mat. no.					7.3 psi	14.5 psi	29 psi	40 psi	43.5 psi	72.5 psi	145 psi
		16 AISI 303	17 <sup>1</sup> AISI 316Ti AISI 316L	30 Brass									
60°	6M2. 404	○	○	○	.05	.03	.13	.19	.26	.31	.32	.42	.59
	6M2. 444	○	○	○	.05	.04	.16	.23	.33	.39	.40	.52	.74
	6M2. 484	○	○	○	.06	.04	.21	.30	.42	.5	.52	.67	.95
	6M2. 514	○	○	○	.06	.04	.25	.35	.50	.59	.62	.79	1.12
	6M2. 564	○	○	○	.08	.05	.33	.47	.66	.78	.81	1.04	1.48
	6M2. 604	○	○	○	.09	.06	.42	.59	.83	.98	1.02	1.32	1.86
	6M2. 644	○	○	○	.10	.06	.53	.75	1.06	1.24	1.29	1.67	2.36
	6M2. 674	○	○	○	.11	.07	.63	.89	1.25	1.47	1.54	1.98	2.81
	6M2. 724	○	○	○	.12	.08	.83	1.18	1.66	1.95	2.04	2.63	3.72
	6M2. 764	○	○	○	.14	.09	1.06	1.50	2.11	2.48	2.59	3.34	4.73
	6M2. 804	○	○	○	.16	.10	1.32	1.87	2.64	3.1	3.24	4.18	5.91
6M2. 844	○	-	-	.18	.12	1.65	2.34	3.30	3.88	4.04	5.22	7.38	
6M2. 884	○	-	○	.20	.13	2.11	2.99	4.23	4.96	5.18	6.68	9.45	
90°	6M2. 446	○	○	○	.05	.03	.16	.23	.33	0.39	.40	.52	.74
	6M2. 486	○	○	○	.06	.03	.21	.30	.42	0.5	.52	.67	.95
	6M2. 516	○	○	○	.06	.04	.25	.35	.50	0.59	.62	.79	1.12
	6M2. 566	○	○	○	.08	.04	.33	.47	.66	0.78	.81	1.04	1.48
	6M2. 606	○	○	○	.09	.05	.42	.59	.83	0.98	1.02	1.32	1.86
	6M2. 646	○	○	○	.10	.05	.53	.75	1.06	1.24	1.29	1.67	2.36
	6M2. 676	○	○	○	.11	.06	.63	.89	1.25	1.47	1.54	1.98	2.81
	6M2. 726	○	○	○	.12	.07	.83	1.18	1.66	1.95	2.04	2.63	3.72
	6M2. 766	○	○	○	.14	.07	1.06	1.50	2.11	2.48	2.59	3.34	4.73
	6M2. 806	○	○	○	.16	.09	1.32	1.87	2.64	3.1	3.24	4.18	5.91
	6M2. 846	-	-	○	.18	.09	1.65	2.34	3.30	3.88	4.04	5.22	7.38
6M2. 886	○	-	○	.20	.12	2.11	2.99	4.23	4.96	5.18	6.68	9.45	
120°	6M2. 517	○	○	○	.06	.04	.25	.35	.50	.59	.62	.79	1.12
	6M2. 567	○	○	○	.08	.04	.33	.47	.66	.78	.81	1.04	1.48
	6M2. 607	○	○	○	.09	.04	.42	.59	.83	.98	1.02	1.32	1.86
	6M2. 647	○	○	○	.10	.05	.53	.75	1.06	1.24	1.29	1.67	2.36
	6M2. 677	○	○	○	.11	.06	.63	.89	1.25	1.47	1.54	1.98	2.81
	6M2. 727	○	○	○	.12	.06	.83	1.18	1.66	1.95	2.04	2.63	3.72
	6M2. 767	○	○	○	.14	.07	1.06	1.50	2.11	2.48	2.59	3.34	4.73
	6M2. 807	○	-	○	.16	.08	1.32	1.87	2.64	3.1	3.24	4.18	5.91
	6M2. 847	-	-	-	.18	.09	1.65	2.34	3.30	3.88	4.04	5.22	7.38
	6M2. 887	-	-	-	.20	.10	2.11	2.99	4.23	4.96	5.18	6.68	9.45

<sup>1</sup>We reserve the right to deliver AISI 316Ti or AISI 316L under the material no. 17.

**Example of ordering:** Type **6M2. 404** + Material no. **16** = Ordering no. **6M2. 404. 16**

### Accessories



Conversion formula for the above series:  $V_2 = V_1 \sqrt{\frac{P_2}{P_1}}$

# Flat fan nozzle with dovetail alignment

## Series 664 / 665

### Series 664 / 665

Assembly with retaining nut. Self aligning jet with dovetail design secures correct spray position for optimal strand surface quality and easy maintenance. Standard version with parabolic liquid distribution.

#### Applications:

Multi and single nozzle arrangements in segments for water only secondary cooling.

- Standard offset angle 15° built into the nozzle
- 0° offset angle available on request 664.xxx.xx.74 or 665.xxx.xx.74

Available also with rectangular liquid distribution for single nozzle arrangement (per roller gap) or wide pitches 664.xxx.xx.90 or 665.xxx.xx.90

Available also with rectangular liquid distribution combined with 0° offset angle for single nozzle arrangement (per roller gap) or wide pitches 664.xxx.xx.96 665.xxx.xx.96 in narrow roller gaps.



#### Special nozzle types:

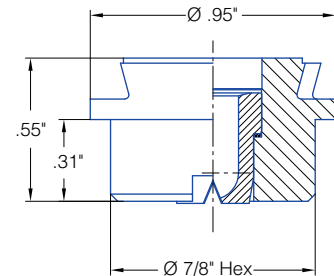
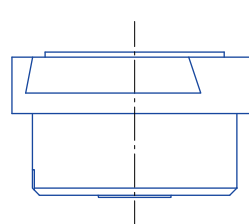
Type + Material No. + Special No

Special No:  
00= standard nozzle

74 = flat jet parallel to dovetail

90 = rectangular liquid distribution

96 = flat jet parallel to dovetail + rectangular liquid distribution




Flat jet 15° offset against dovetail

Spray angle	Ordering no.				Equivalent Orifice diam. (in.)	Free passage (in.)	Flow Rate (Gallons Per Minute)						Spray Coverage @ 30 psi		
	Type	Material no.					10 psi	20 psi	liters per minute 2 bar	40 psi	60 psi	80 psi	100 psi	H=10"	H=20"
		303 SS 16	316 SS 17 <sup>1)</sup>	Brass 30											
20°	664. 721	○	○	○	.118	.099	.98	1.4	6.3	2.0	2.4	2.8	3.1	4	8
	664. 801	○	○	○	.158	.126	1.6	2.2	10.0	3.1	3.8	4.4	4.9	4	8
	664. 881	○	○	○	.197	.158	2.5	3.5	16.0	5.0	6.1	7.0	7.8	4	8
	664. 921	○	○	○	.217	.173	3.1	4.4	20.0	6.2	7.6	8.8	9.8	4	8
	664. 961	○	○	○	.236	.201	3.9	5.5	25.0	7.8	9.5	11.0	12.3	4	8
30°	664. 722	○	○	○	.118	.095	.98	1.4	6.3	2.0	2.4	2.8	3.1	6	11
	664. 762	○	○	○	.138	.106	1.2	1.8	8.0	2.5	3.0	3.5	3.9	6	11
	664. 802	○	○	○	.158	.122	1.6	2.2	10.0	3.1	3.8	4.4	4.9	6	11
	664. 882	○	○	○	.197	.158	2.5	3.5	16.0	5.0	6.1	7.0	7.8	6	11
	664. 922	○	○	○	.217	.173	3.1	4.4	20.0	6.2	7.6	8.8	9.8	6	11
	664. 962	○	○	○	.236	.197	3.9	5.5	25.0	7.8	9.5	11.0	12.3	6	11
	665. 042	○	-	○	.315	.252	6.2	8.8	40.0	12.4	15.2	17.6	19.6	6	11
665. 122	-	-	○	.394	.323	9.8	13.8	63.0	19.5	23.9	27.6	30.9	6	11	

1) We reserve the right to deliver material 316 SS or 316L SS, if we show the material code 17.

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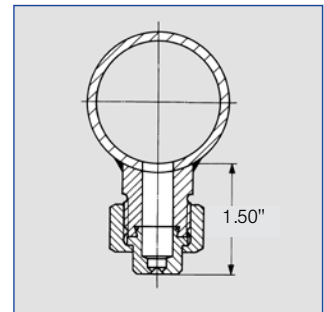
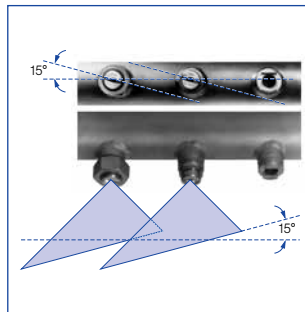
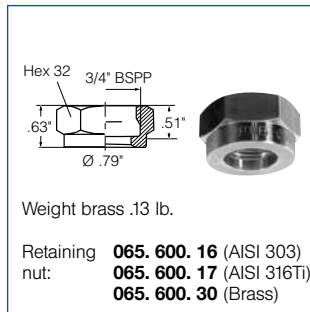
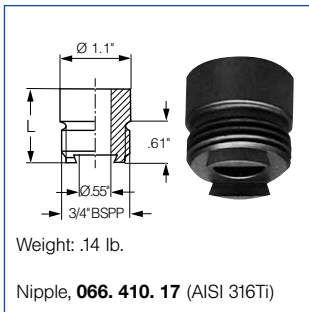


Spray angle 	Ordering no.			Equivalent Orifice diam. (in.)	Free passage (in.)	Flow Rate (Gallons Per Minute)						Spray Coverage @ 30 psi			
	Type	Material no.				10 psi	20 psi	liters per minute 2 bar	40 psi	60 psi	80 psi	100 psi	H=10"	H=20"	
		16 <small>303 SS</small>	17 <sup>1)</sup> <small>316 SS</small>												30 <small>Brass</small>
45°	664. 723	○	○	○	.118	.095	.98	1.4	6.3	2.0	2.4	2.8	3.1	10	19
	664. 763	○	○	○	.138	.102	1.2	1.8	8.0	2.5	3.0	3.5	3.9	10	19
	664. 803	○	○	○	.158	.118	1.6	2.2	10.0	3.1	3.8	4.4	4.9	10	19
	664. 843	○	○	○	.177	.134	1.9	2.7	12.5	3.9	4.8	5.5	6.1	10	19
	664. 883	○	○	○	.197	.150	2.5	3.5	16.0	5.0	6.1	7.0	7.8	10	20
	664. 923	○	○	○	.217	.165	3.1	4.4	20.0	6.2	7.6	8.8	9.8	11	20
	664. 963	○	○	○	.236	.183	3.9	5.5	25.0	7.8	9.5	11.0	12.3	11	20
	665. 043	-	-	○	.315	.232	6.2	8.8	40.0	12.4	15.2	17.6	19.6	11	20
60°	664. 724	○	○	○	.118	.083	.98	1.4	6.3	2.0	2.4	2.8	3.1	12	22
	664. 764	○	○	○	.138	.091	1.2	1.8	8.0	2.5	3.0	3.5	3.9	12	22
	664. 804	○	○	○	.158	.102	1.6	2.2	10.0	3.1	3.8	4.4	4.9	12	22
	664. 844	○	○	○	.177	.118	1.9	2.7	12.5	3.9	4.8	5.5	6.1	12	22
	664. 884	○	○	○	.197	.134	2.5	3.5	16.0	5.0	6.1	7.0	7.8	12	22
	664. 924	○	○	○	.217	.162	3.1	4.4	20.0	6.2	7.6	8.8	9.8	12	23
	664. 964	○	○	○	.236	.165	3.9	5.5	25.0	7.8	9.5	11.0	12.3	12	23
	665. 044	○	○	○	.315	.217	6.2	8.8	40.0	12.4	15.2	17.6	19.6	12	23
90°	664. 726	○	○	○	.118	.200	.98	1.4	6.3	2.0	2.4	2.8	3.1	17	31
	664. 766	○	○	○	.138	.300	1.2	1.8	8.0	2.5	3.0	3.5	3.9	17	31
	664. 806	○	○	○	.158	.095	1.6	2.2	10.0	3.1	3.8	4.4	4.9	17	31
	664. 846	○	○	○	.177	.095	1.9	2.7	12.5	3.9	4.8	5.5	6.1	17	31
	664. 886	○	○	○	.197	.122	2.5	3.5	16.0	5.0	6.1	7.0	7.8	17	31
	664. 926	○	○	○	.217	.142	3.1	4.4	20.0	6.2	7.6	8.8	9.8	17	31
	664. 966	○	○	○	.236	.154	3.9	5.5	25.0	7.8	9.5	11.0	12.3	17	31
	665. 046	-	-	○	.315	.193	6.2	8.8	40.0	12.4	15.2	17.6	19.6	17	31
120°	664. 727	○	○	○	.118	.063	.98	1.4	6.3	2.0	2.4	2.8	3.1	49	85
	664. 767	○	○	○	.138	.067	1.2	1.8	8.0	2.5	3.0	3.5	3.9	49	85
	664. 807	○	○	○	.158	.079	1.6	2.2	10.0	3.1	3.8	4.4	4.9	49	85
	664. 887	○	○	○	.197	.102	2.5	3.5	16.0	5.0	6.1	7.0	7.8	49	85
	664. 927	○	○	○	.217	.114	3.1	4.4	20.0	6.2	7.6	8.8	9.8	49	85
	664. 967	-	-	○	.236	.126	3.9	5.5	25.0	7.8	9.5	11.0	12.3	49	85
	665. 047	-	-	○	.315	.173	6.2	8.8	40.0	12.4	15.2	17.6	19.6	49	85

**Example**    Type    +    Material no.    =    Ordering no.  
for ordering: 664. 727    +    16                    =    664. 727. 16

1) We reserve the right to deliver material 316 SS, if we show the material code 17.

### Accessories



# Flat fan nozzle with increased spray depth and dovetail alignment

## Series 600.280

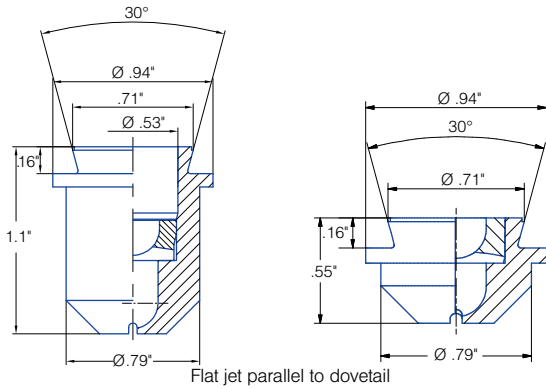
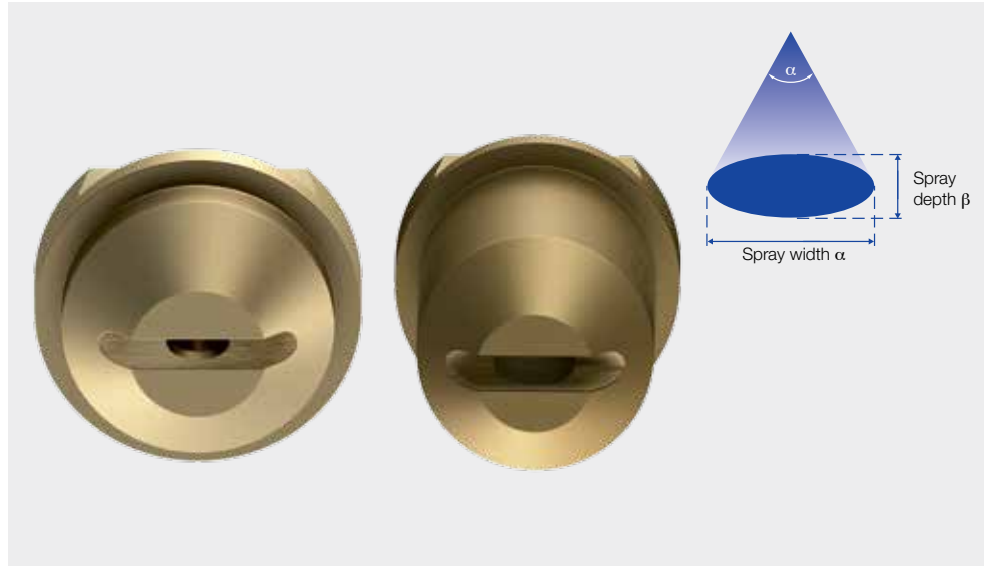
### Series 600.280

Assembly with 3/4" retaining nut. Self-aligning jet with dovetail design with 0° offset angle secures correct spray position for optimal strand surface quality and easy maintenance.

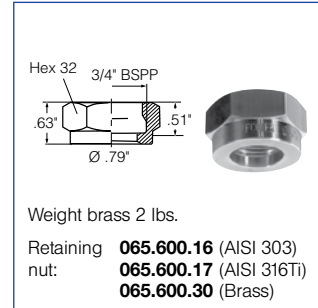
- Typically with trapezoid liquid distribution
- Available in .55" short and in 1.1" long version

### Applications:


Single and multi nozzle arrangements in segments for water only secondary cooling in bloom and slab casters. Also suitable for vertical spray positions such as narrow side cooling in slab casters or vertical spray cooling in bloom casters.



### Accessories



Spray angle	Ordering no.	Mat. no.		Spray depth angle [°]	Length [in]	Narrowest cross section [in]	Flow Rate (Gallons Per Minute)						
		Type	16				30	10 psi	20 psi	liters per minute 2 bar	40 psi	80 psi	100 psi
			303 SS				Brass						
60°	600.280.xx.34	○	○	12	1.1	.12	2.66	3.68	16.60	5.10	7.07	7.85	
	600.280.xx.32	○	○	15	1.1	.12	2.66	3.68	16.60	5.10	7.07	7.85	
	600.280.xx.28	○	○	20	1.1	.1	1.89	2.62	11.80	3.63	5.02	5.58	
	600.280.xx.29	○	○	20	1.1	.12	2.61	3.62	16.30	5.01	6.94	7.71	
	600.280.xx.30	○	○	20	1.1	.14	3.32	4.59	20.70	6.36	8.81	9.79	
	600.280.xx.33	○	○	25	1.1	.16	3.56	4.93	22.20	6.82	9.45	10.49	
	600.280.xx.83	○	○	40	1.1	.04	0.29	0.40	1.80	0.55	0.77	0.85	
	600.280.xx.12	○	○	40	1.1	.04	0.42	0.58	2.60	0.80	1.11	1.23	
	600.280.xx.11	○	○	40	1.1	.04	0.46	0.64	2.90	0.89	1.23	1.37	
	600.280.xx.22	○	○	40	1.1	.08	1.04	1.44	6.50	2.00	2.77	3.07	
600.280.xx.21	○	○	40	1.1	.1	1.36	1.89	8.50	2.61	3.62	4.02		
70°	600.280.xx.17	○	○	40	1.1	.04	0.29	0.40	1.80	0.55	0.77	0.85	
	600.280.xx.15	○	○	40	1.1	.04	0.42	0.58	2.60	0.80	1.11	1.23	
	600.280.xx.84	○	○	40	1.1	.07	0.69	0.95	4.30	1.32	1.83	2.03	
75°	600.280.xx.82	○	○	15	1.1	.07	1.27	1.75	7.90	2.43	3.36	3.73	
	600.280.xx.16	○	○	15	1.1	.07	1.36	1.89	8.50	2.61	3.62	4.02	
	600.280.xx.19	○	○	30	1.1	.06	0.74	1.02	4.60	1.41	1.96	2.17	
	600.280.xx.26	○	○	30	1.1	.07	0.91	1.26	5.70	1.75	2.43	2.69	

Spray angle 	Ordering no.		Spray depth angle [°]	Length [in]	Narrowest cross section [in]	Flow Rate (Gallons Per Minute)						
	Type	Mat. no.				10 psi	20 psi	liters per minute 2 bar	40 psi	80 psi	100 psi	
		16 303 SS										30 Brass
80°	600.280.xx.64	○	○	20	1.1	.06	0.45	0.62	2.80	0.86	1.19	1.32
	600.280.xx.74	○	○	20	1.1	.06	0.50	0.69	3.10	0.95	1.32	1.47
	600.280.xx.51	○	○	25	1.1	.06	2.23	3.08	13.90	4.27	5.92	6.57
	600.280.xx.42	○	○	30	.55	.04	0.50	0.69	3.10	0.95	1.32	1.47
90°	600.280.xx.77	○	○	20	1.1	.04	0.99	1.38	6.20	1.91	2.64	2.93
	600.280.xx.14	○	○	20	1.1	.04	1.09	1.51	6.80	2.09	2.89	3.21
	600.280.xx.08	○	○	20	1.1	.09	1.89	2.62	11.80	3.63	5.02	5.58
	600.280.xx.03	○	○	20	1.1	.08	2.13	2.95	13.30	4.09	5.66	6.29
	600.280.xx.05	○	○	20	1.1	.10	2.58	3.57	16.10	4.95	6.85	7.61
	600.280.xx.09	○	○	20	1.1	.08	2.61	3.62	16.30	5.01	6.94	7.71
	600.280.xx.10	○	○	20	1.1	.11	3.32	4.59	20.70	6.36	8.81	9.79
	600.280.xx.62	○	○	27	1.1	.06	1.03	1.42	6.40	1.97	2.72	3.03
	600.280.xx.69	○	○	27	1.1	.09	1.55	2.15	9.70	2.98	4.13	4.59
	600.280.xx.68	○	○	27	1.1	.12	1.89	2.62	11.80	3.63	5.02	5.58
	600.280.xx.72	○	○	27	1.1	.11	2.87	3.97	17.90	5.50	7.62	8.46
	600.280.xx.76	○	○	27	1.1	.11	3.35	4.64	20.90	6.42	8.90	9.88
	600.280.xx.13	○	○	30	.55	.04	0.29	0.40	1.80	0.55	0.77	0.85
	600.280.xx.97	○	○	30	1.1	.05	0.43	0.60	2.70	0.83	1.15	1.28
	600.280.xx.92	○	○	30	.55	.05	0.43	0.60	2.70	0.83	1.15	1.28
	600.280.xx.41	○	○	30	.55	.06	0.74	1.02	4.60	1.41	1.96	2.17
	600.280.xx.95	○	○	30	1.1	.07	0.74	1.02	4.60	1.41	1.96	2.17
	600.280.xx.90	○	○	30	.55	.07	0.75	1.04	4.70	1.44	2.00	2.22
	600.280.xx.27	○	○	30	1.1	.07	1.12	1.55	7.00	2.15	2.98	3.31
	600.280.xx.63	○	○	30	1.1	.09	1.30	1.80	8.10	2.49	3.45	3.83
	600.280.xx.45	○	○	30	1.1	.09	1.83	2.53	11.40	3.50	4.85	5.39
	600.280.xx.66	○	○	30	1.1	.08	2.58	3.57	16.10	4.95	6.85	7.61
	600.280.xx.24	○	○	30	1.6	.08	2.58	3.57	16.10	4.95	6.85	7.61
	600.280.xx.73	○	○	35	1.1	.09	1.68	2.33	10.50	3.23	4.47	4.96
	600.280.xx.81	○	○	40	1.1	.07	0.43	0.60	2.70	0.83	1.15	1.28
	600.280.xx.79	○	○	40	1.1	.06	0.67	0.93	4.20	1.29	1.79	1.99
	600.280.xx.80	○	○	40	1.1	.07	0.86	1.20	5.40	1.66	2.30	2.55
	600.280.xx.78	○	○	40	1.1	.10	1.62	2.24	10.10	3.10	4.30	4.77
100°	600.280.xx.53	○	○	15	2.2	.10	2.63	3.64	16.40	5.04	6.98	7.75
	600.280.xx.44	○	○	15	1.1	.11	4.45	6.17	27.80	8.54	11.83	13.14
	600.280.xx.85	○	○	25	1.1	.06	0.91	1.26	5.70	1.75	2.43	2.69
	600.280.xx.50	○	○	25	1.1	.06	1.09	1.51	6.80	2.09	2.89	3.21
	600.280.xx.07	○	○	25	1.1	.09	2.58	3.57	16.10	4.95	6.85	7.61
	600.280.xx.88	○	○	30	.55	.05	0.43	0.60	2.70	0.83	1.15	1.28
	600.280.xx.58	○	○	30	.55	.07	0.77	1.06	4.80	1.48	2.04	2.27
	600.280.xx.57	○	○	30	.55	.07	1.07	1.49	6.70	2.06	2.85	3.17
	600.280.xx.40	○	○	30	1.1	.06	1.12	1.55	7.00	2.15	2.98	3.31
	600.280.xx.56	○	○	30	.55	.07	1.36	1.89	8.50	2.61	3.62	4.02
	600.280.xx.55	○	○	30	.55	.10	1.65	2.29	10.30	3.17	4.38	4.87
	600.280.xx.36	○	○	30	.55	.10	1.99	2.75	12.40	3.81	5.28	5.86
	600.280.xx.59	○	○	40	1.1	.10	1.75	2.42	10.90	3.35	4.64	5.15
	600.280.xx.35	○	○	40	1.1	.10	1.95	2.71	12.20	3.75	5.19	5.77
	600.280.xx.37	○	○	40	1.1	.11	3.14	4.35	19.60	6.02	8.34	9.27
	600.280.xx.23	○	○	50	1.1	.07	0.42	0.58	2.60	0.80	1.11	1.23
	600.280.xx.31	○	○	50	1.1	.05	0.72	1.00	4.50	1.38	1.92	2.13
	105°	600.280.xx.02	○	○	23	.55	.04	0.74	1.02	4.60	1.41	1.96
600.280.xx.00		○	○	23	.55	.05	1.04	1.44	6.50	2.00	2.77	3.07
600.280.xx.01		○	○	23	.55	.06	1.36	1.89	8.50	2.61	3.62	4.02
600.280.xx.04		○	○	23	.55	.05	1.67	2.31	10.40	3.20	4.43	4.92
600.280.xx.65		○	○	27	1.1	.04	0.45	0.62	2.80	0.86	1.19	1.32
600.280.xx.67		○	○	27	1.1	.06	0.64	0.89	4.00	1.23	1.70	1.89
112°	600.280.xx.43	○	○	30	1.1	.09	2.07	2.86	12.90	3.96	5.49	6.10

Conversion formula for the above series:  $V_2 = V_1 \sqrt{\frac{P_2}{P_1}}$

Materials: 30 (Brass), 16 (stainless steel) on request.  
Other nozzle types on request.



# Flat fan nozzle with increased spray depth and dovetail alignment

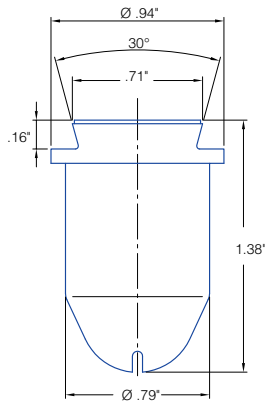
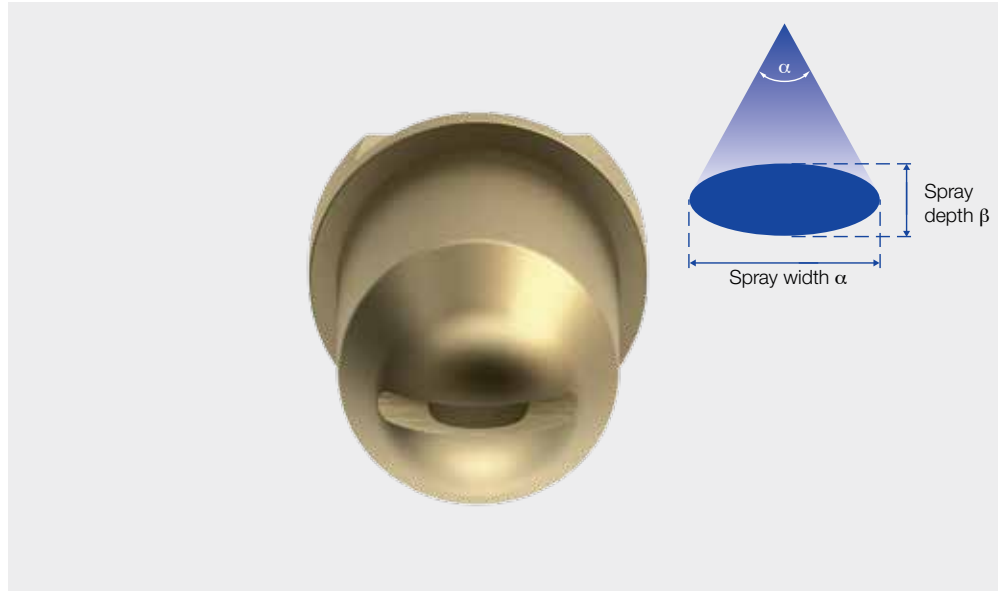
## Series 600.366

### Series 600.366

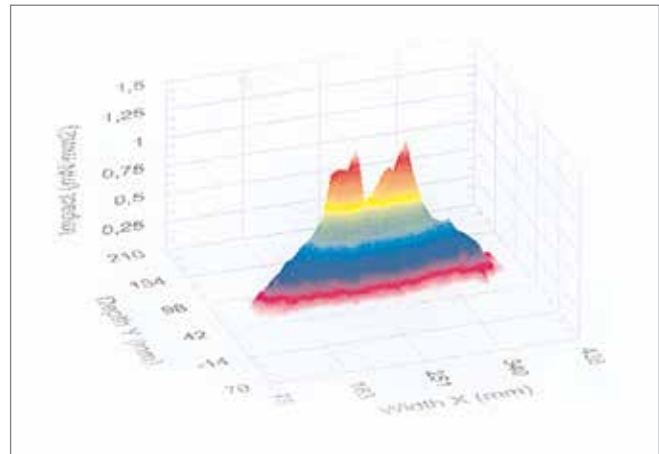
**High impact version** with peak center liquid distribution.

Assembly with 3/4" retaining nut. Self aligning jet with dovetail design with 0° offset angle secures correct spray position for optimal strand surface quality and easy maintenance.

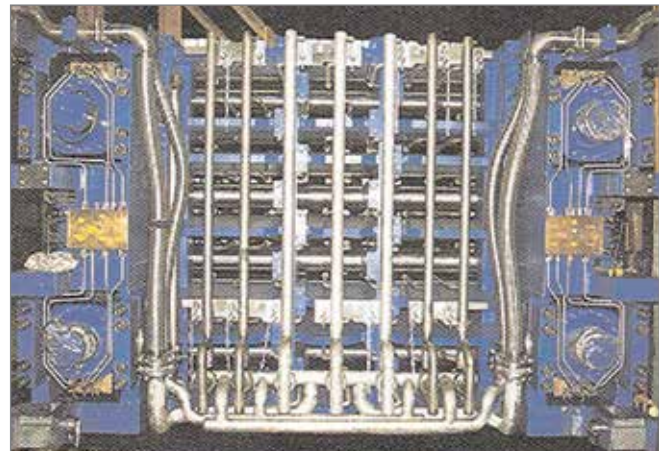
**Applications:**  
Multi nozzle arrangements in segments for water only secondary cooling, especially in thin slab high speed casters.




Flat jet parallel to dovetail



Typical impact measurement of high impact version

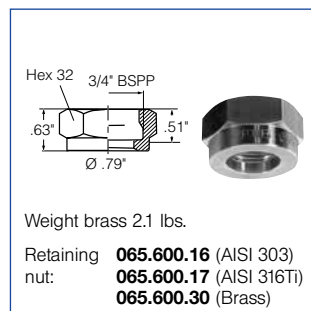


Position-controlled segments for LCR operation of a CSP plant, pre-assembled in the work shop.

Spray angle 	Ordering no.		Spray depth angle [°]	Length [in]	Narrowest cross section [in]	Flow Rate (Gallons Per Minute)					
	Type	Mat. no.				10 psi	20 psi	liters per minute 2 bar	40 psi	80 psi	100 psi
		16 303 SS	30 Brass								
68°	600.366.xx.53	○	68	19	.04	0.29	0.40	1.80	0.55	0.77	0.85
	600.366.xx.55	○	68	19	.05	0.45	0.62	2.80	0.86	1.19	1.32
69°	600.366.xx.70	○	69	26	.04	0.19	0.27	1.20	0.37	0.51	0.57
	600.366.xx.72	○	69	26	.06	0.53	0.73	3.30	1.01	1.40	1.56
70°	600.366.xx.50	○	70	20	.06	0.59	0.82	3.70	1.14	1.57	1.75
	600.366.xx.13	○	70	30	.07	0.61	0.84	3.80	1.17	1.62	1.80
	600.366.xx.51	○	70	20	.08	0.74	1.02	4.60	1.41	1.96	2.17
	600.366.xx.14	○	70	30	.07	1.09	1.51	6.80	2.09	2.89	3.21
74°	600.366.xx.54	○	74	19	.05	0.37	0.51	2.30	0.71	0.98	1.09
	600.366.xx.56	○	74	19	.06	0.67	0.93	4.20	1.29	1.79	1.99
75°	600.366.xx.60	○	75	26	.07	1.03	1.42	6.40	1.97	2.72	3.03
80°	600.366.xx.71	○	80	26	.05	0.35	0.49	2.20	0.68	0.94	1.04
	600.366.xx.61	○	80	26	.07	1.19	1.64	7.40	2.27	3.15	3.50
82°	600.366.xx.52	○	82	28	.07	1.09	1.51	6.80	2.09	2.89	3.21
83°	600.366.xx.30	○	83	20	.07	0.74	1.02	4.60	1.41	1.96	2.17
90°	600.366.xx.36	○	90	20	.06	0.95	1.31	5.90	1.81	2.51	2.79
	600.366.xx.37	○	90	20	.07	1.43	1.97	8.90	2.74	3.79	4.21
102°	600.366.xx.48	○	102	32	.06	0.95	1.31	5.90	1.81	2.51	2.79
105°	600.366.xx.49	○	105	25	.04	0.37	0.51	2.30	0.71	0.98	1.09
	600.366.xx.23	○	105	20	.04	0.43	0.60	2.70	0.83	1.15	1.28
	600.366.xx.28	○	105	20	.04	0.59	0.82	3.70	1.14	1.57	1.75
	600.366.xx.40	○	105	20	.05	0.74	1.02	4.60	1.41	1.96	2.17
	600.366.xx.00	○	105	35	.07	0.74	1.02	4.60	1.41	1.96	2.17
	600.366.xx.44	○	105	20	.07	0.99	1.38	6.20	1.91	2.64	2.93
	600.366.xx.41	○	105	20	.07	1.09	1.51	6.80	2.09	2.89	3.21
	600.366.xx.21	○	105	20	.08	1.12	1.55	7.00	2.15	2.98	3.31
	600.366.xx.01	○	105	35	.08	1.12	1.55	7.00	2.15	2.98	3.31
	600.366.xx.42	○	105	20	.07	1.41	1.95	8.80	2.70	3.75	4.16
	600.366.xx.22	○	105	20	.09	1.49	2.06	9.30	2.86	3.96	4.40
	600.366.xx.02	○	105	35	.09	1.49	2.06	9.30	2.86	3.96	4.40
	600.366.xx.43	○	105	20	.08	1.79	2.48	11.20	3.44	4.77	5.29
	600.366.xx.03	○	105	35	.10	1.86	2.57	11.60	3.56	4.94	5.48
600.366.xx.45	○	105	20	.08	2.24	3.11	14.00	4.30	5.96	6.62	
108°	600.366.xx.80	○	108	32	.09	1.89	2.62	11.80	3.63	5.02	5.58
	600.366.xx.81	○	108	32	.09	2.16	3.00	13.50	4.15	5.75	6.38
110°	600.366.xx.47	○	110	28	.04	0.61	0.84	3.80	1.17	1.62	1.80

Other nozzle types on request.

## Accessories



Conversion formula for the above series:  $V_2 = V_1 \sqrt{\frac{P_2}{P_1}}$

# Axial-flow full cone nozzles Series 490

## Series 490

Non-clogging nozzle design. Stable spray angle. Particularly even liquid distribution.

### Applications:

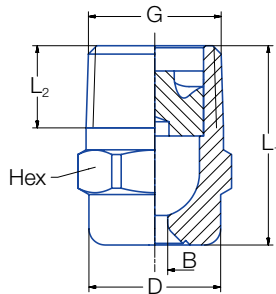
Strand cooling in billet casters, strand narrow side cooling in slab casters, spray cooling of billet molds, spray cooling of EAF electrodes after use.

### Remark:

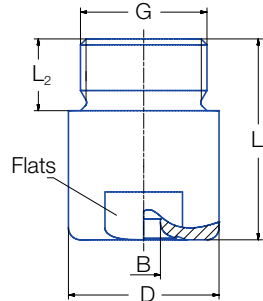
Material combination **T8** brass for the nozzle housing and AISI 316L for the vane, or completely made from AISI 316L **1Y** is recommended if the nozzles will be exposed to high temperatures for longer periods of time.



Series 490



Code  
BC-BG



Code  
BK-BM

Code	Dimensions (in.)					Weight Brass
	G	L <sub>1</sub>	L <sub>2</sub>	D	Hex/Flat	
<b>BC</b>	1/4 NPT	0.87	0.39	0.51	9/16	.04
<b>BE</b>	3/8 NPT	0.96	0.39	0.63	11/16	.07
<b>BE</b>	3/8 NPT	1.18	0.39	0.63	11/16	.11
<b>BG</b>	1/2 NPT	1.28	0.51	0.83	14/16	.13
<b>BG</b>	1/2 NPT	1.71	0.51	0.83	14/16	.19
<b>BK</b>	3/4 NPT	1.65	0.59	1.26	1-1/16	.42
<b>BK</b>	3/4 NPT	1.97	0.59	1.26	1-1/16	.44
<b>BM</b>	1 NPT	2.20	0.67	1.57	1-7/16	.77

Subject to technical modification.

In a critical installation situation, please ask for the exact dimensions.

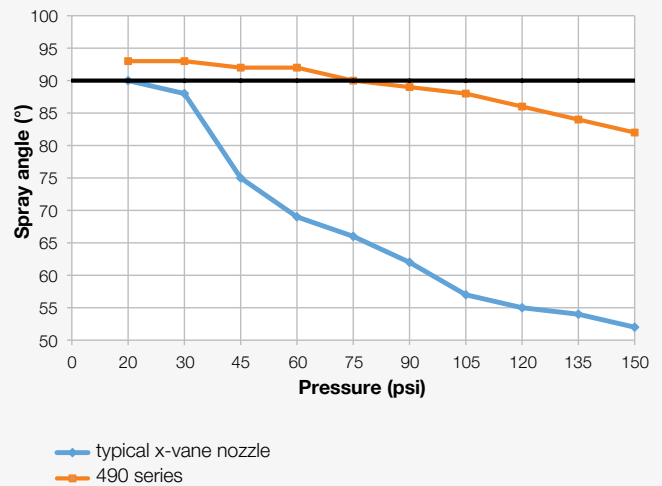
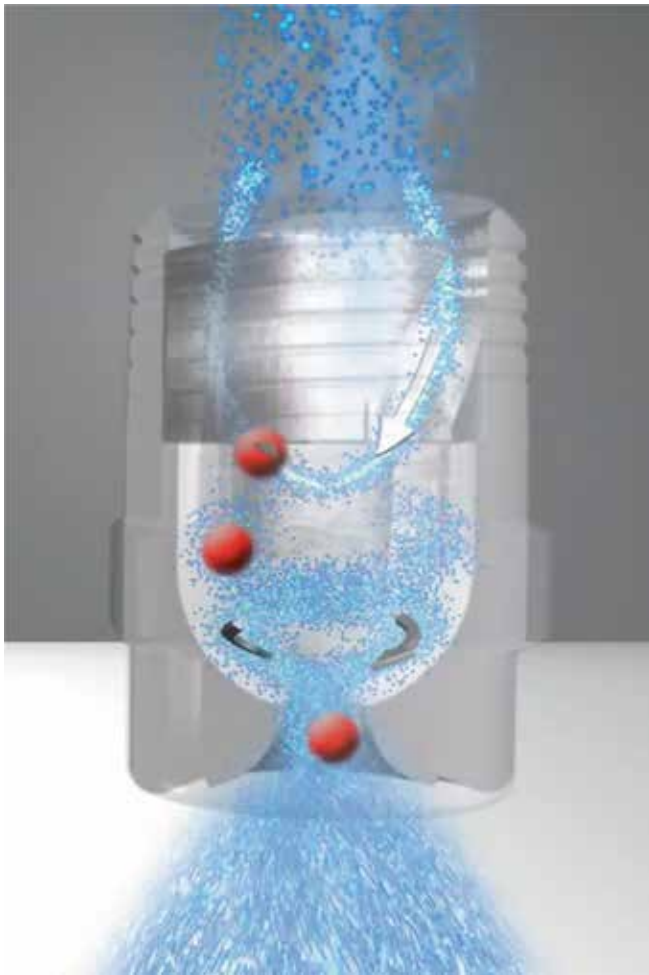
## New nozzle generation with an innovative internal design providing the nozzle with:

30 % to 40 % larger compared to conventional axial full cone nozzles  
Non clogging characteristics due to larger free cross sections

Extended machine availability and reduced maintenance costs

Stable spray angle over pressure range

No over- or under cooling of strand corners and center section improves quality



Spray angle of 490 series compared to typical x-vane nozzle for various water pressures





Solid particle passing through 490 nozzle series



Solid particle passing through conventional axial full cone nozzle



# Axial-flow full cone nozzles

## Series 490

Spray angle 	Ordering no.								Orifice diam. (in.)	Free Passage (in.)	Flow Rate (Gallons Per Minute)							Spray Diam. D (in.) @ 30 psi 		
	Type	Mat. no.			Connection						10 psi	20 psi	liters per minute 2 bar	40 psi	80 psi	100 psi	150 psi	H=8"	H=20"	
		1Y	30	Brass/ AISI 316L T8	Male NPT															
					1/8"	1/4"	3/8"	1/2"												3/4"
45°	490. 403	○	○	○	BA	-	-	-	-	.049	.049	.17	.23	1.00	.30	.40	.43	.51	6	16
	490. 443	○	○	○	-	BC	-	-	-	.06	.06	.19	.25	1.25	.39	.48	.54	.63	6	16
	490. 523	○	○	○	BA	-	-	-	-	.067	.067	.35	.46	2.00	.60	.79	.87	1.02	6	16
	490. 563	○	○	○	-	BC	-	-	-	.07	.07	.38	.5	2.5	.78	.95	1.09	1.25	6	16
	490. 603	○	○	○	-	BC	BE	-	-	.079	.079	.54	.72	3.15	.95	1.25	1.37	1.61	6	16
	490. 643	-	○	○	-	-	BE	-	-	.096	.098	.69	.91	4.00	1.20	1.59	1.73	2.04	6	16
	490. 683	-	○	○	-	-	BE	-	-	.100	.100	.86	1.14	5.00	1.50	1.98	2.17	2.55	6	16
	490. 703	-	○	○	-	-	BE	-	-	.104	.104	.97	1.27	5.60	1.68	2.22	2.43	2.85	6	16
	490. 723	○	○	○	-	-	BE	-	-	.112	.112	1.09	1.43	6.30	1.89	2.50	2.73	3.21	6	16
	490. 783	-	○	○	-	-	-	BG	-	.136	.136	1.55	2.05	9.00	2.70	3.57	3.90	4.58	6	16
490. 843	-	○	○	-	-	-	BG	-	.150	.150	2.16	2.85	12.50	3.76	4.96	5.42	6.37	6	16	
60°	490. 404	○	○	○	BA	-	-	-	-	.045	.045	.17	0.23	1.00	.30	.40	.43	0.51	9	22
	490. 444	○	-	○	BA	-	-	-	-	.049	.049	.22	0.29	1.25	.38	.49	.54	0.64	9	22
	490. 484	○	○	○	BA	-	-	-	-	.057	.057	.28	0.36	1.60	.48	.63	.69	0.82	9	22
	490. 524	○	○	○	BA	-	-	-	-	.063	.063	.35	0.46	2.00	.60	.79	.87	1.02	9	22
	490. 564	○	○	○	BA	-	-	-	-	.071	.071	.43	0.57	2.50	.75	.99	1.08	1.27	9	22
	490. 604	○	○	○	BA	BC	BE	-	-	.081	.081	.54	0.72	3.15	.95	1.25	1.37	1.61	9	22
	490. 644	○	○	○	-	BC	BE	-	-	.091	.091	.69	0.91	4.00	1.20	1.59	1.73	2.04	9	22
	490. 684	○	○	○	-	BC	BE	-	-	.102	.102	.86	1.14	5.00	1.50	1.98	2.17	2.55	9	22
	490. 704	○	○	○	-	-	BE	-	-	.11	.11	.85	1.12	5.6	1.74	2.13	2.44	2.82	9	22
	490. 724	○	○	○	-	BC	BE	-	-	.112	.110	1.09	1.43	6.30	1.89	2.50	2.73	3.21	9	22
	490. 744	○	○	○	-	-	BE	-	-	.12	.12	1.08	1.42	7.10	2.21	2.71	3.1	3.57	9	22
	490. 764	○	○	○	-	-	BE	-	-	.128	.128	1.38	1.82	8.00	2.40	3.17	3.47	4.08	9	22
	490. 804	○	○	○	-	-	BE	-	-	.146	.146	1.72	2.28	10.00	3.00	3.97	4.34	5.10	9	22
	490. 844	○	○	○	-	-	-	BG	-	.159	.159	2.16	2.85	12.50	3.76	4.96	5.42	6.37	9	22
	490. 884	○	○	○	-	-	-	BG	-	.183	.183	2.76	3.64	16.00	4.81	6.34	6.94	8.16	9	22
	490. 924	○	○	○	-	-	-	BK	-	.205	.205	3.45	4.56	20.00	6.01	7.93	8.67	10.20	9	22

Continued on next page.



Spray angle 	Ordering no.								Orifice diam. (in.)	Free Passage (in.)	Flow Rate (Gallons Per Minute)							Spray Diam. D (in.) @ 30 psi 		
	Type	Mat. no.			Connection						10 psi	20 psi	liters per minute 2 bar	40 psi	80 psi	100 psi	150 psi	H=8"	H=20"	
		1Y	30	T8	Male NPT															
					1/8"	1/4"	3/8"	1/2"												3/4"
90°	490.406	○	○	○	BA	-	-	-	-	.047	.047	.17	.23	1.00	.30	.40	.43	.51	15	34
	490.446	-	○	○	BA	-	-	-	-	.051	.051	.22	.29	1.25	.38	.49	.54	.64	15	34
	490.486	○	○	○	BA	-	-	-	-	.057	.057	.28	.36	1.60	.48	.63	.69	.82	15	34
	490.506	○	○	○	-	BC	-	-	-	.06	.06	.27	.36	1.80	.56	.69	.78	.91	15	34
	490.526	○	○	○	BA	-	-	-	-	.067	.067	.35	.46	2.00	.60	.79	.87	1.02	15	34
	490.566	○	○	○	BA	-	-	-	-	.075	.075	.43	.57	2.50	.75	.99	1.08	1.27	15	34
	490.606	○	○	○	BA	-	BE	-	-	.081	.081	.54	.72	3.15	.95	1.25	1.37	1.61	15	34
	490.646	○	○	○	-	BC	BE	-	-	.094	.094	.69	.91	4.00	1.20	1.59	1.73	2.04	15	38
	490.686	○	○	○	-	BC	BE	-	-	.106	.106	.86	1.14	5.00	1.50	1.98	2.17	2.55	15	38
	490.726	○	○	○	-	BC	BE	-	-	.126	.110	1.09	1.43	6.30	1.89	2.50	2.73	3.21	15	38
	490.746	○	○	○	-	-	BE	-	-	.124	.124	1.23	1.62	7.10	2.13	2.82	3.08	3.62	15	38
	490.766	○	○	○	-	-	BE	-	-	.134	.134	1.38	1.82	8.00	2.40	3.17	3.47	4.08	15	38
	490.806	○	○	○	-	-	BE	-	-	.154	.154	1.72	2.28	10.00	3.00	3.97	4.34	5.10	15	38
	490.846	○	○	○	-	-	BE	-	-	.183	.157	2.16	2.85	12.50	3.76	4.96	5.42	6.37	15	38
	490.886	○	○	○	-	-	-	BG	-	.215	.177	2.76	3.64	16.00	4.81	6.34	6.94	8.16	15	38
490.926	○	○	○	-	-	-	BG	-	.232	.177	3.45	4.56	20.00	6.01	7.93	8.67	10.20	15	38	
120°	490.368	○	○	○	BA	-	-	-	-	.033	.026	.11	.14	.63	.19	.25	.27	.32	27	48
	490.408	○	○	○	BA	-	-	-	-	.047	.047	.17	.23	1.00	.30	.40	.43	.51	27	48
	490.448	○	○	○	BA	-	-	-	-	.051	.051	.22	.29	1.25	.38	.49	.54	.64	27	48
	490.488	○	○	○	BA	-	-	-	-	.057	.057	.28	.36	1.60	.48	.63	.69	.82	27	48
	490.528	○	○	○	BA	-	-	-	-	.067	.067	.35	.46	2.00	.60	.79	.87	1.02	27	48
	490.568	○	○	○	BA	-	-	-	-	.075	.075	.43	.57	2.50	.75	.99	1.08	1.27	27	48
	490.608	○	○	○	-	-	-	-	-	.083	.081	.54	.72	3.15	.95	1.25	1.37	1.61	27	48
	490.648	○	○	○	-	BC	BE	-	-	.094	.094	.69	.91	4.00	1.20	1.59	1.73	2.04	27	52
	490.688	○	○	○	-	BC	BE	-	-	.108	.108	.86	1.14	5.00	1.50	1.98	2.17	2.55	27	52
	490.728	○	○	○	-	BC	BE	-	-	.126	.110	1.09	1.43	6.30	1.89	2.50	2.73	3.21	27	52
	490.748	○	○	○	-	-	BE	-	-	.126	.126	1.23	1.62	7.10	2.13	2.82	3.08	3.62	27	52
	490.768	○	○	○	-	-	BE	-	-	.136	.136	1.38	1.82	8.00	2.40	3.17	3.47	4.08	27	52
	490.808	○	○	○	-	-	BE	-	-	.154	.154	1.72	2.28	10.00	3.00	3.97	4.34	5.10	27	52
	490.848	○	○	○	-	-	BE	-	-	.185	.157	2.16	2.85	12.50	3.76	4.96	5.42	6.37	27	52
	490.888	○	○	○	-	-	-	BG	-	.201	.177	2.76	3.64	16.00	4.81	6.34	6.94	8.16	27	52
490.928	○	○	○	-	-	-	BG	-	.228	.228	3.45	4.56	20.00	6.01	7.93	8.67	10.20	27	52	

Example    Type    +    Material no.    +    Conn.    =    Ordering no.  
for ordering: 490.368 + 1Y                    + BA                    = 490.368.1Y.BA

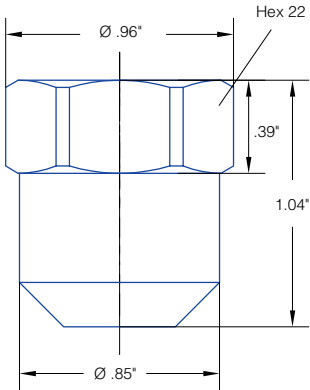
# Axial-flow full cone nozzles


## Series 486

### Series 486

The classical full cone nozzles with R 3/8" female thread connection. Circular uniform full cone spray pattern.

**Applications:**  
Very common in "Concast" billet casters.




Spray angle 	Ordering no.				Code	Flow Rate (Gallons Per Minute)					
	Type	Mat. no.		Thread R 3/8" female		10 psi	20 psi	liters per minute 2.8 bar	40 psi	80 psi	100 psi
		30 Brass	1C AISI 304								
45°	486. 443	○	○	AF	1545L	0.18	0.25	1.30	0.34	0.47	0.52
	486. 493	○	○	AF	2045L	0.24	0.33	1.70	0.45	0.61	0.67
	486. 533	○	○	AF	2545L	0.30	0.40	2.10	0.55	0.75	0.83
	486. 563	○	○	AF	3045L	0.37	0.50	2.60	0.68	0.93	1.03
	486. 593	○	○	AF	3545L	0.42	0.58	3.00	0.79	1.08	1.19
	486. 613	○	○	AF	4045L	0.48	0.65	3.40	0.89	1.22	1.35
	486. 633	○	○	AF	4545L	0.55	0.75	3.90	1.02	1.40	1.55
	486. 653	○	○	AF	5045L	0.60	0.83	4.30	1.13	1.54	1.70
	486. 663	○	○	AF	5545L	0.66	0.90	4.70	1.23	1.68	1.86
	486. 683	○	○	AF	6045L	0.73	1.00	5.20	1.36	1.86	2.06
	486. 713	○	○	AF	7045L	0.84	1.15	6.00	1.57	2.15	2.38
	486. 733	○	○	AF	8045L	0.97	1.33	6.90	1.81	2.47	2.73
	486. 783	○	○	AF	10045L	1.21	1.65	8.60	2.26	3.08	3.41
	486. 813	○	○	AF	12045L	1.45	1.98	10.30	2.70	3.69	4.08
65°	486. 394	○	○	AF	1065L	0.14	0.19	1.0	0.26	0.36	0.40
	486. 454	○	○	AF	1665L	0.23	0.31	1.6	0.42	0.57	0.63
	486. 494	○	○	AF	2065L	0.28	0.38	2.0	0.52	0.72	0.79
	486. 524	○	○	AF	2065L	0.28	0.38	2.0	0.52	0.72	0.79
	486. 534	○	○	AF	2565L	0.35	0.48	2.5	0.66	0.90	0.99
	486. 564	○	○	AF	3065L	0.42	0.58	3.00	0.79	1.08	1.19
	486. 565	○	○	AF	3065L	0.42	0.58	3.0	0.79	1.08	1.19
	486. 594	○	○	AF	3565L	0.49	0.67	3.5	0.92	1.25	1.39
	486. 604	○	○	AF	3865L	0.53	0.73	3.8	1.00	1.36	1.51
	486. 614	○	○	AF	4065L	0.56	0.77	4.0	1.05	1.43	1.59
	486. 624	○	○	AF	4265L	0.59	0.81	4.2	1.10	1.51	1.66
	486. 634	○	○	AF	4565L	0.63	0.86	4.5	1.18	1.61	1.78
	486. 654	○	○	AF	5065L	0.70	0.96	5.0	1.31	1.79	1.98
	486. 664	○	○	AF	5565L	0.77	1.06	5.5	1.44	1.97	2.18
	486. 674	○	○	AF	5565L	0.77	1.06	5.5	1.44	1.97	2.18
	486. 684	○	○	AF	6065L	0.84	1.15	6.0	1.57	2.15	2.38
	486. 704	○	○	AF	6065L						
	486. 714	○	○	AF	7065L	0.84	1.15	6.00	1.57	2.15	2.38
	486. 724	○	○	AF	7565L						
	486. 734	○	○	AF	8065L	0.97	1.33	6.90	1.81	2.47	2.73
	486. 744	○	○	AF	8565L						
	486. 764	○	○	AF	9565L	1.41	1.92	10	2.62	3.58	3.96
	486. 774	○	○	AF	10065L	1.21	1.65	8.60	2.26	3.08	3.41
	486. 814	○	○	AF	12065L	1.69	2.31	12.0	3.15	4.30	4.76
	486. 844	○	○	AF	14665L	2.05	2.80	14.6	3.83	5.23	5.79
	486. 854	○	○	AF	15065L						
	486. 864	○	○	AF	16565L	1.45	1.98	10.30	2.70	3.69	4.08

Other nozzle types on request.  
Pressure-flow diagrams on request.

# Axial-flow full cone nozzles

## Series 486

Spray angle 	Ordering no.				Code	Flow Rate (Gallons Per Minute)					
	Type	Mat. no.		Thread R 3/8" female		10 psi	20 psi	liters per minute 2.8 bar	40 psi	80 psi	100 psi
		30 Brass	1C AISI 304								
65°	486. 704	○	○	AF	6565L	0.91	1.25	6.5	1.71	2.33	2.58
	486. 714	○	○	AF	7065L	0.98	1.34	7.0	1.84	2.51	2.77
	486. 724	○	○	AF	7565L	1.05	1.44	7.5	1.97	2.69	2.97
	486. 734	○	○	AF	8065L	1.13	1.54	8.0	2.10	2.87	3.17
	486. 744	○	○	AF	8565L	1.20	1.63	8.5	2.23	3.05	3.37
	486. 764	○	○	AF	9565L	1.34	1.83	9.5	2.49	3.41	3.77
	486. 774	○	○	AF	10065L	1.41	1.92	10.0	2.62	3.58	3.96
	486. 814	○	○	AF	12065L	1.69	2.31	12.0	3.15	4.30	4.76
	486. 844	○	○	AF	14665L	2.05	2.80	14.6	3.83	5.23	5.79
	486. 854	○	○	AF	15065L	2.11	2.88	15.0	3.94	5.38	5.95
486. 864	○	○	AF	16565L	2.32	3.17	16.5	4.33	5.92	6.54	
90°	486. 446	○	○	AF	1590L	0.21	0.29	1.5	0.39	0.54	0.59
	486. 496	○	○	AF	2090L	0.28	0.38	2	0.52	0.72	0.79
	486. 536	○	○	AF	2590L	0.35	0.48	2.5	0.66	0.90	0.99
	486. 566	○	○	AF	3090L	0.42	0.58	3.0	0.79	1.08	1.19
	486. 596	○	○	AF	3590L	0.49	0.67	3.5	0.92	1.25	1.39
	486. 606	○	○	AF	3890L	0.53	0.73	3.8	1.00	1.36	1.51
	486. 616	○	○	AF	4090L	0.56	0.77	4.0	1.05	1.43	1.59
	486. 636	○	○	AF	4590L	0.63	0.86	4.5	1.18	1.61	1.78
	486. 646	○	○	AF	4690L	0.70	0.95	4.6	1.30	1.78	1.97
	486. 656	○	○	AF	5090L	0.70	0.96	5.0	1.31	1.79	1.98
	486. 686	○	○	AF	6090L	0.84	1.15	6.0	1.57	2.15	2.38
	486. 706	○	○	AF	6590L	0.91	1.25	6.5	1.71	2.33	2.58
	486. 726	○	○	AF	7590L	1.05	1.44	7.5	1.97	2.69	2.97
	486. 736	○	○	AF	8090L	1.13	1.54	8.0	2.10	2.87	3.17
	486. 766	○	○	AF	9590L	1.34	1.83	9.5	2.49	3.41	3.77
	486. 776	○	○	AF	10090L	1.41	1.92	10	2.62	3.58	3.96
	486. 806	○	○	AF	10090L	1.41	1.92	10	2.62	3.58	3.96
	486. 816	○	○	AF	12090L	1.69	2.31	12.0	3.15	4.30	4.76
	486. 846	○	○	AF	14690L	2.05	2.80	14.6	3.83	5.23	5.79

Other nozzle types on request.  
Pressure-flow diagrams on request.

# Oval full cone nozzle

## Series 400.291

### Series 400.291

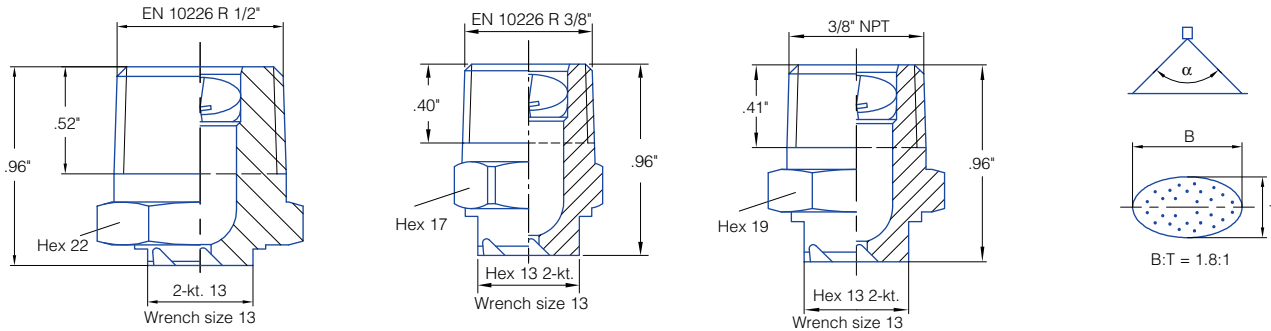
Oval full cone spray pattern  
90° x 60°

#### Applications:

Single and multi nozzle arrangements in segments for water only secondary cooling in bloom and slab casters. Ideal for foot roller spray positions in order to prevent mould edge erosion by replacing flat fan nozzles. Also suitable for vertical spray positions such as narrow side cooling in slab casters or vertical spray cooling in bloom casters.



Series 400.291



Ordering no.	Thread				Narrowest cross section (in.)	Flow Rate (Gallons Per Minute)					
	3/8 NPT	R 1/2"	R 3/8"	R 3/8" secured		10 psi	20 psi	liters per minute 2 bar	40 psi	80 psi	100 psi
400. 291. 30. X6	○	-	○	○	.04	0.32	0.44	2.00	0.61	0.85	0.95
400. 291. 30. X4	○	-	○	○	.05	0.43	0.60	2.70	0.83	1.15	1.28
400. 291. 30. X5	○	○	○	○	.06	0.54	0.75	3.40	1.04	1.45	1.61
400. 291. 30. X0	○	○	○	○	.07	0.70	0.98	4.40	1.35	1.87	2.08
400. 291. 30. X1	○	-	○	-	.08	0.95	1.31	5.90	1.81	2.51	2.79
400. 291. 30. X2	○	-	○	-	.08	1.09	1.51	6.80	2.09	2.89	3.21
400. 291. 30. X7	-	-	○	-	.13	2.56	3.55	16.00	4.92	6.81	7.56

Materials: 30 (Brass), 16 (stainless steel) on request.  
Other nozzle types on request.  
Pressure-flow diagrams on request.

3/8 NPT: X=1  
R 1/2: X=7  
R 3/8: X=0  
3/8 NPT secured: X=5

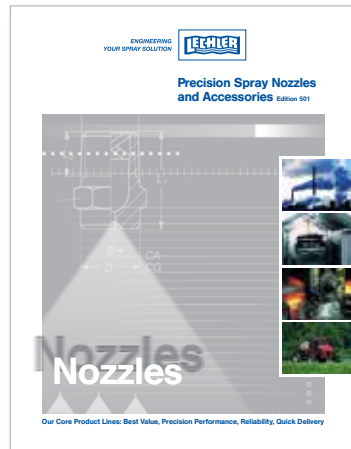
To complete the final ordering no., please replace "X" by the corresponding NPT / R value.

Conversion formula for the above series:  $V_2 = V_1 \sqrt{\frac{P_2}{P_1}}$

# YOU CAN FIND MORE NOZZLES IN OUR STANDARD CATALOG ...

The catalog "Precision Spray Nozzles and Accessories" is a sought-after manual of nozzle technology.

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We have a collection of information, included in individual subject brochures, covering special nozzles that are also of particular interest to continuous casting.

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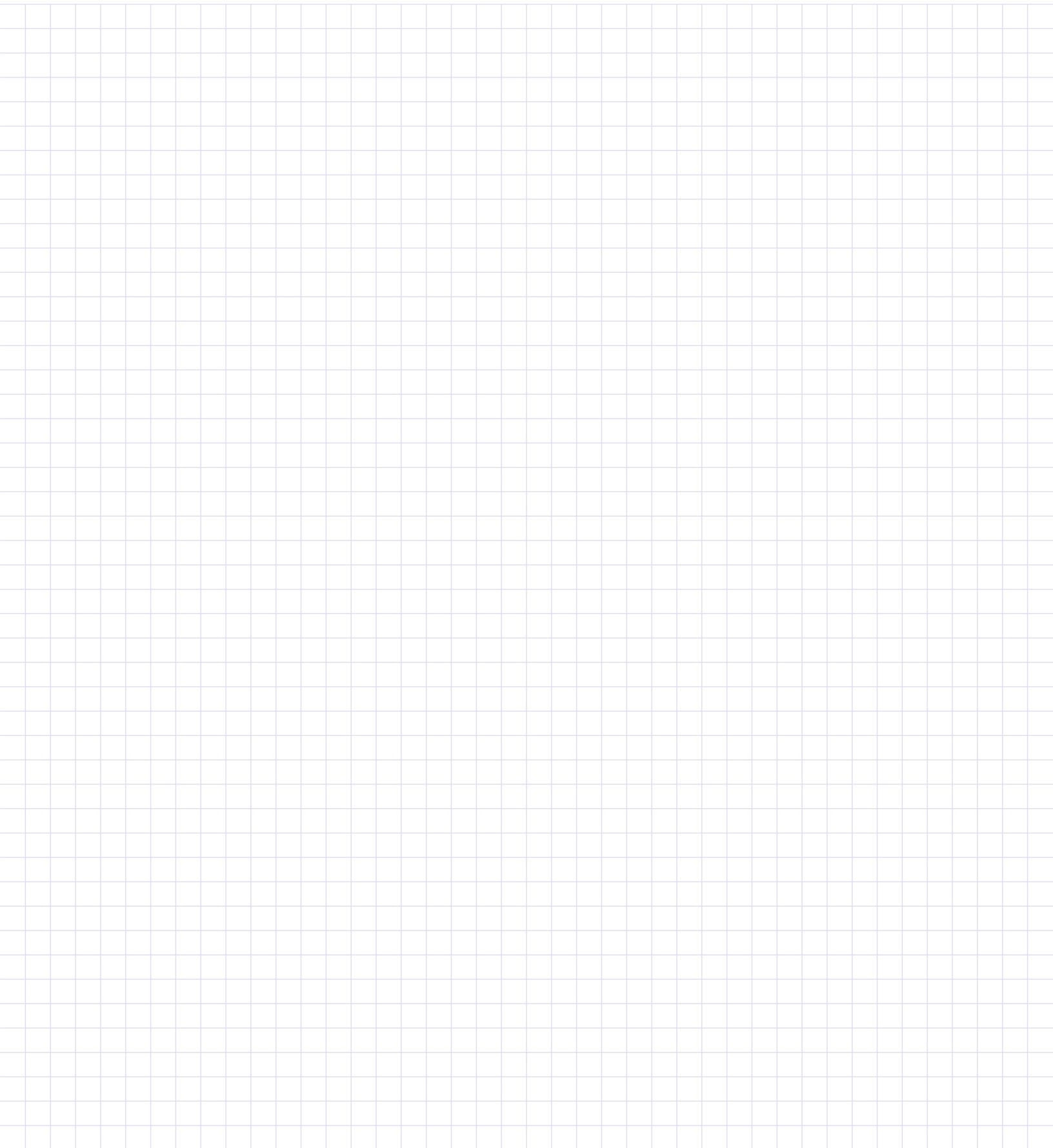
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