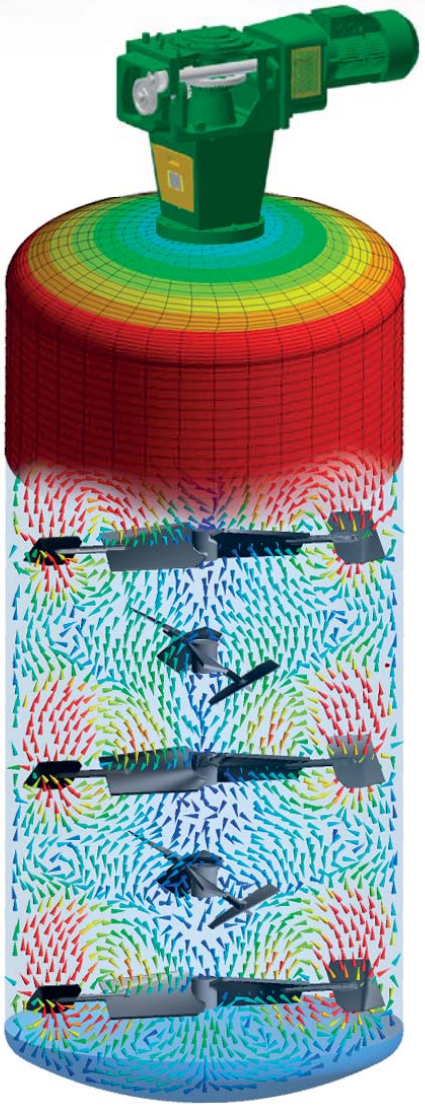
SPX®

When Mixing Matters

MIXING TECHNOLOGY FROM LIGHTNIN



Lightnin®

A World Leader in Industrial Mixing since 1923, Lightnin has 90 years of unrivaled experience in industrial mixing technology, process knowledge, and technological innovation. Lightnin enjoys a global reputation for durable, long-lasting mixers, agitators, aerators, and flocculators for fluid process systems. We offer a full spectrum of impeller designs for diverse applications. In addition, we offer a worldwide service network, mixer repair, gearbox repair, and replacement parts programs. Look to Lightnin for knowledge, technology, and service excellence.

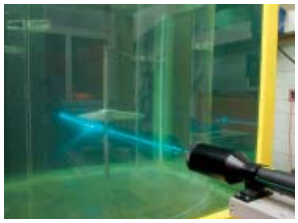
Based in Charlotte, North Carolina, SPX Corporation (NYSE: SPW) is a global, multi-industry manufacturing leader with approximately $5 billion in annual revenue, operations in more than 35 countries and over 14,000 employees. The company's highly-specialized, engineered products and technologies are concentrated in Flow Technology and energy infrastructure. Many of SPX's innovative solutions are playing a role in helping to meet rising global demand for electricity and processed foods and beverages, particularly in emerging markets. The company's products include food processing systems for the food and beverage industry, critical Flow components for oil and gas processing, power transformers for utility companies, and cooling systems for power plants. For more information, please visit www.spx.com.

Lightnin Mixers

ADVANCED SOLUTIONS FOR OPTIMIZED PROCESS PERFORMANCE

At the heart of SPX's continuous development program is its dedicated, industry-leading research center. Used on a daily basis to support its customer base, the extensively equipped facility is manned by highly talented researchers and engineers, producing innovative solutions for difficult mixing applications and ensuring that the Lightnin brand remains at the forefront of Mixing Technology.





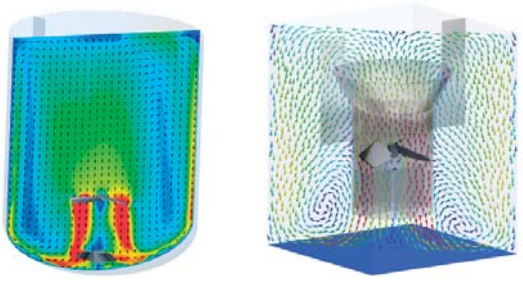
LDV — Laser Doppler Velocimeter

Efficient mixing is at the heart of most successful process operations. Our Laser Doppler Velocimeter (LDV) allows us to accurately establish a given impeller's performance. Power, speed, and shaft loading measurements are taken simultaneously with the fluid flow data, allowing a full understanding of each impeller's unique operating characteristics to be established.



Scale Testing — Laboratory, Through Pilot Scale to Full Scale Production

We can test your process from laboratory, through pilot scale to full scale production. SPX's Lightnin laboratory is fully equipped to model test any mixing application whether it be liquid-liquid, liquid-solid, gas-liquid, or gas-liquid-solid. Whenever possible we prefer to test your actual material, or to use a suitable simulant that mimics the rheological properties of your process. Our dedicated Explosion-Proof laboratory area can be used for hazardous materials testing. Our testing capability ranges from 200 ml to 2000 m^3 (8 fl.oz. to over 500,000 US gal.). Using SPX's proven scale-up/scale-down techniques and experience, we can confidently predict full-scale equipment design requirements.



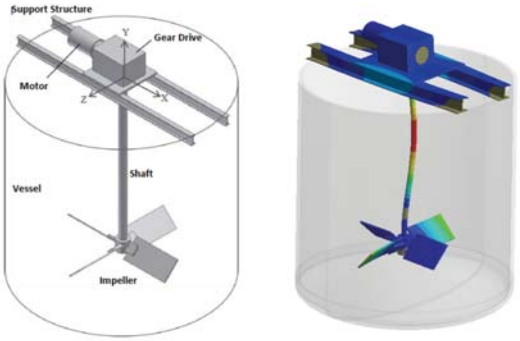
CFD — Computational Fluid Dynamics Software

LDV data and scale model testing is augmented by state-of-the-art Computational Fluid Dynamics (CFD) software. CFD models the combined dynamic effects of impeller design, vessel geometry, and fluid properties. This powerful capability allows quick evaluation of existing process mixing problems, and significantly reduces the cost of pilot scale experiments and full-scale trials.

ENGINEERED PRODUCTS — ASSURED OPERATION

The depth of technical knowledge gained from more than 90 years of operating experience and an installed base exceeding 1 million units is supported by state-of-the-art analytical design tools.

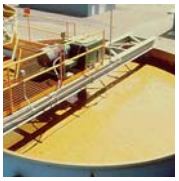
Finite Element Analysis (FEA) is often employed to carry out mechanical, thermal, and vibration analysis and is used extensively by SPX in the development of new products and custom engineering of specific applications. We can look at stress levels and structural deflections of individual components and complete agitators, as well as full vibration analysis of the agitation system, supporting structure, and agitation vessel. An increasingly common practice in many industrial processing plants is vibration level monitoring of rotating equipment. Our engineers use FEA to provide guidance on optimal locations and expected vibration levels for monitoring, as well as provide valuable information for troubleshooting should any vibration levels increase over the life of the system. This combined Modal/Harmonic analysis can be used to prevent premature mechanical failures and avoid problematic process conditions to ensure that maximum efficiency and run time is obtained — protecting both machinery and profitability. We have the know-how and the ability to ensure total system integrity for your application.



A modal analysis conducted on a typical large mixer-vessel structure system.

Application Knowledge

SPX has a process solution for a wide variety of mixing applications. Mixing applications can be broken down into the following mixing duties: liquid-liquid, liquid-solid, gas-liquid, gas-liquid-solid, and fluid motion. Many applications are often a combination of these duties and thus having a full understanding of each of these areas is crucial to recommending an optimized design that is also economical.



Liquid-Liquid

- Solvent extraction of copper and other metals
- Continuous pH control in potable water or effluent treatment
- Blending of additives and ingredients in food and beverages

Liquid-Solid

- Petroleum blending and drilling mud suspension
- Blending of additives and ingredients in food and beverages
- Draft tube crystallizers, used in the production of alumina
- Suspension of slurries in large tanks at slurry pipeline facilities

Gas-Liquid

- Flue-gas desuplurization for municipal and industrial power plants
- Hydrogenation for chemical and pharmaceutical industries

Gas-Liquid-Solid

- Pressure oxidation and high pressure acid leach autoclave mixers
- Fermentation, a key process step in many biopharma and biofuel plants
- Surface aeration and anoxic mixing basins at industrial and municipal water/waste water treatment plants

Fluid Motion

- Milk storage and cream aging for dairies
- Homogenization of storage tanks

Axial Flow Impellers

A310/A510 (CORE IMPELLER TECHNOLOGY)

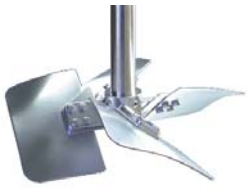
Low blade solidity hydrofoil, recommended for low viscosity blending and solid suspension applications:

- Varying tip chord angle allows for further optimization of mixer selection
- Maximizes flow generation while minimizing fluid shear
- The A310 is standard for all Lightnin gear drive portable mixers
- Generates the same flow as a pitched bladed turbine (A200) for 60% of the power and 50% of the torque

A312

Hydrofoil design of choice for side entering mixer applications:

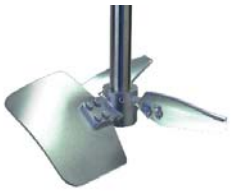
- Designed to handle demanding pulp and paper applications and oil storage applications
- Focused axial flow creates good flow penetration in large diameter tanks
- Generates the same process results as traditional propeller style impellers with up to 50% power savings
- Has been successfully used for draft tube crystallizer applications



A315 (CORE IMPELLER TECHNOLOGY)

High solidity hydrofoil design recommended for gas-liquid dispersion and mass transfer applications:

- High blade solidity improves gas handling by up to 3 times that of a conventional hydrofoil impeller such as the A510
- Generates strong axial flow, which reduces staging that occurs with radial flow impellers in tall reactors
- Can improve mass transfer by 30% compared with a Rushton impeller (R100)
- Operates at lower torque than a conventional radial flow impeller, thus reducing capital costs



A320 (CORE IMPELLER TECHNOLOGY)

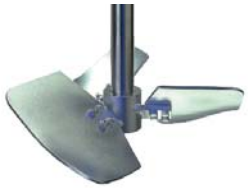
High solidity hydrofoil design recommended for high viscosity blending applications:

- High efficiency wide-bladed impeller design with high flow/power ratio
- Improved axial flow at low Reynolds numbers (N re <500) reduces power requirements by up to 50% over a pitch blade turbine (A200) for equal blending performance
- Has also been successfully used for gas handling applications

CLEAN EDGE

Specifically designed as a non-stringing axial flow impeller:

- Unique blade design resists ragging, making it suitable for low viscosity applications where ragging material is present
- Produces strong axial flow in low viscosity fluids with similar flow/power performance as an A510 hydrofoil



A340/A345

Recommended for up pumping multi-phase mixing applications with high gas rates:

- Handles a high level of gas without flooding as compared to radial flow and down pumping axial flow impellers
- Creates strong gas induction at the liquid surface, which helps to induce escaped gas back into the batch
- Strong axial velocities created at the tank wall improve heat transfer in jacketed vessels
- Multiple impellers work together to create good axial flow within the tank, thus reducing staging as seen with multiple radial flow impellers

A6000 (COMPOSITE MATERIAL)

Recommended for low viscosity blending / solid suspension applications in hostile environments:

- 25% more flow efficient than an A310/A510 impeller
- Constructed out of a high grade vinyl ester resin, which is lightweight, strong, and highly corrosion-resistant
- Excellent for use in acids, caustics, chlorinated solutions, and other aggressive chemicals where stainless steels are not suitable
- A cost-effective solution versus high alloys such as Hastelloy and Titanium

A100

Recommended for portable mixer applications where moderate pumping action with powder wetting is required:

- Used for direct drive portable mixer applications
- Superpitch design (1.5 pitch ratio) for greater mixing capabilities
- Generates good axial flow
- Also used for special side entering mixer applications (smelt dissolving)

A200

Recommended for low to medium viscosity blending and solids suspension applications:

- Classic 45 degree pitch blade turbine (PBT) design
- Although replaced by the A510, this impeller is still applicable in cases where some fluid shear is required (e.g., solids make-down and viscous applications)
- Can be customized with varying blade widths and blade angles (A201)

FOLDING PROPELLER

Recommended for mixing in vessels with narrow ports:

- Two folding blades that fully open when impeller rotates
- Good for low viscosity blending and solids suspension

Clean Edge in Action

Have you ever seen Municipal Waste Treatment applications where the severe service causes premature failure and excessive maintenance?

Pictured to the right is an Anoxic Mixer at a WWTP in Florida. The hydrofoil impellers installed here bind up with rags and other fibrous materials until the blades, shaft, or mixer drive require maintenance and/or replacement.

Lightnin introduces a solution to this “dirty problem” in Municipal and Industrial treatment services.

The Clean Edge impeller pictured to the right remains free of fibrous debris while delivering performance equal to a hydrofoil impeller.

The Clean Edge impeller has also been used successfully in Side Entry applications on sludge storage and in paper stock duties where stringing fibrous material is in the tank.

See the Clean Edge in Action on YouTube, use the QR-Code, or navigate to the SPX Corporation Channel on YouTube.

SPX®

FLOW

LIGHTNIN Impe

AXIAL FLOW

A200

A340

A315

A100

A6000

A320

CO
IMPE
TECHN

C200

A312

A310 &
A510

Clean Edge

SPECIALTY

A620

R320/

A400

R400

R300

eller Spectrum

SHEAR

RADIAL FLOW

R100

R200

RE
LLER
OLOGY

R130

R600

R510

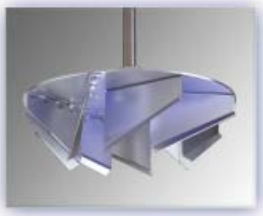
R135

R500

KT-3

IMPELLERS

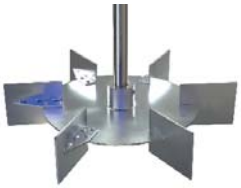
R320D



R335

A245

MBI



Radial Flow Impellers

R130 (GAS HANDLING)

Recommended for high shear mixing and gas dispersion applications:

- Half pipe shaped blades improve gas handling over the R100 impeller while reducing torque requirements by up to 40%
- Radial design provides shear to achieve good contacting for liquid-liquid and gas-liquid dispersions and emulsions
- Can be customized with varying blade widths and lengths (R131)

R135 (LOW TORQUE GAS HANDLING)

Parabolic radial flow impeller recommended for high shear mixing and gas dispersion applications:

- Optimized parabolic blade shape improves gas handling ability by 20% and reduces torque requirements by 40% over an R130
- Radial design provides shear to achieve good contacting for liquid-liquid and gas-liquid dispersions and emulsions

R100 (RUSHTON)

Recommended for high shear mixing and gas dispersion applications:

- Classic 90-degree flat blade turbine design (Rushton impeller)
- Radial design provides shear to achieve good contacting for liquid-liquid and gas-liquid dispersions and emulsions
- Can be customized with varying blade widths and lengths (R101)

R600 (SPIRAL BACKSWEPT)

Spiral backswept flat bladed turbine, used as close clearance mixing impeller near the bottom of a tank for low viscosity applications. The impeller is used in Smelt Dissolver applications in pulp and paper plants.

R500/R510 (SAWTOOTH-HIGH SHEAR / BAR TURBINE-HIGH SHEAR)

The R500 is a sawtooth impeller providing the highest shear of any impeller available. The R500 typically requires an additional impeller (A310/A200) to provide the necessary flow to blend the tank's contents. The R510, a bar turbine, provides high shear while developing additional flow to circulate the tank's contents. Both impellers are recommended for high shear applications with elements that are difficult to disperse.

KT-3 in Action

The KT-3 impeller is specifically designed and shaped to sit inside and nearly parallel to the tank bottom profile of an ASME dish or shallow cone. Its performance has been evaluated at multiple scales with significant results.

In one case, a solids heel was reduced 98.9% by adding the KT-3.

A310 kicker to the left, product still visible in tank.

KT-3 kicker to the left, no product left in tank.

See the KT-3 in Action on YouTube, use the QR-Code, or navigate to the SPX Corporation Channel on YouTube.

Specialty Impellers

A620 (HIGH VISCOSITY-LOW REYNOLDS NUMBERS)

Recommended for non-Newtonian transitional flow blending, where Reynolds numbers are between 50 and 500:

- Optimal two-bladed design creates downflow in the center and upflow at the wall, creating a complete turnover of the tank's contents
- Provides similar blend time for less power than traditional open impellers (A320, A200) and less torque (lower cost) than traditional close clearance impellers (A400, R400)

R400 (ANCHOR-LOW REYNOLDS NUMBERS)

Traditional anchor style wiper impeller recommended for ultra-high viscosity blending applications at low Reynolds numbers (Nre <10).

R320/R320D (HIGH CAPACITY-PUMPER IMPELLERS)

Curved bladed pumper style impeller recommended for solvent extraction pumper applications:

- Optimized curved bladed design produces the same flow and head as a flat bladed pumper impeller for 30% power reduction
- Lower shear optimizes dispersion droplet size, improving mass transfer between phases while reducing crud formation
- Increased hydraulic efficiency permits use of smaller gearboxes
- Available in stainless steel, high alloy, and composites

A400 (DOUBLE SPIRAL-LOW REYNOLDS NUMBERS)

Traditional spiral impeller recommended for ultra-high viscosity blending applications at low Reynolds numbers (Nre< 10).

R335 (SURFACE AERATOR)

Surface aerator impeller used for waste water treatment basins:

- Low discharge directory, thus improving splash and overall flow pattern
- Up to 25% more efficient than a pitch blade turbine (A200)
- Reduced splash height for low headroom operation and cold climate operation

A245 (SURFACE AERATOR)

High efficiency aeration impeller:

- "Splash guard" improves aeration efficiency by channeling water radially away from the impeller
- Enhanced spray improves oxygen transfer rate
- Reduced splash height for low headroom operation and cold climate operation
- Efficiency improvement of up to 20%

C200 (DRAFT TUBE IMPELLER)

Recommended for draft tube applications:

- Airfoil blade design maximizes flow and head generation while reducing power requirements
- Tip speed is minimized with impeller, thus improving impeller wear in tough draft tube applications
- Varying tip chord angle allows for mixer selection optimization
- Standard impeller of choice for Alumina Draft Tube Precipitators

KT-3 (LOW LEVEL MIXING WITH SOLIDS)

Specifically designed for low-level mixing in dished and shallow coned bottoms with a bottom outlet:

- Generates an asymmetric flow pattern in the tank bottom, swirling the tank's contents in order to remove slurry from the tank while minimizing solids buildup
- Lower torque requirements with improved performance over more traditional paddles and pitch blade turbines

Advanced Technology Provides Predictable Mixing Results

IMPELLER SELECTION

Fluid mixing is a key operation in the design of many processes. Proper impeller selection allows for an optimized mixer selection by minimizing both power and torque. Minimizing power will lead to a lower annual cost to operate the mixer while minimizing torque will typically lead to a lower initial investment cost.

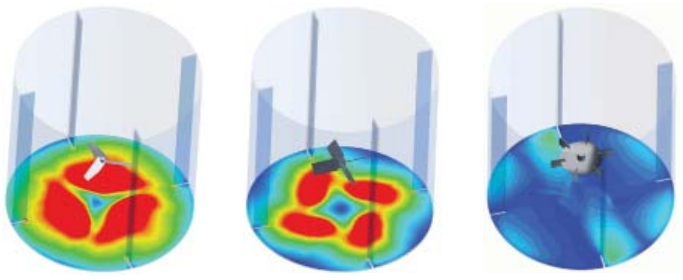
The impeller generates a flow pattern within the vessel and also imparts energy to the fluid. How an impeller accomplishes both of these will affect the process result (whether it be blending two fluids together or suspending solids).

An example comparing the energy dissipation at the bottom of the vessel is shown to the right. The Lightnin A510 impeller generates the most energy dissipation at the bottom of the vessel versus the pitch blade turbine (PBT) and Rushton turbine for the same diameter, D, and power, P. This is why the A510 requires less power to suspend solids than both the A200 and R100. To get equal performance, a more costly mixer design would be required for both the A200 and R100. A comparison in Table 1 illustrates this. The energy dissipation at the floor of the tank is shown in the CFD to the right.

Table 1. An Impeller Design Comparison and Impact on Cost of Ownership

IMPELLER TYPE	D/T	GEARBOX SIZE	RELATIVE CAPITAL COST	RELATIVE OPERATING COST	RELATIVE STRUCTURAL COST
A510-22	0.34	Size 1	1.00	1.00	1.00
PBT	0.34	Size 2	1.22	1.83	1.78
Rushton	0.34	Size 5	2.80	3.00	2.00

Energy Dissipation at Bottom of Tank, (Equal D and P for Each Impeller)



A510 PBT Rushton Turbine

IMPELLER COMPARISON BASIC FORMULAE

Not all impellers perform at a similar level of efficiency even though they may look similar in design. The performance capability of flow impellers can be compared by an evaluation of flow efficiency. Knowledge of the flow numbers (Nq) and power number (Np) of the impellers being compared is required.

The following basic equations can then be applied:

1) $Np = \frac{P}{N^3D^5\rho}$

2) $Nq = \frac{Q}{ND^3}$

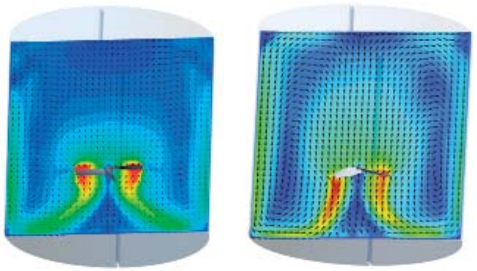
3) $Nre = \frac{ND^2\rho}{\mu}$

Where:
- Np = Impeller power number
- N = Impeller rotational speed
- Nq = Impeller flow number
- Nre = Impeller Reynolds number
- μ = Viscosity in Pas
- P = Impeller power
- D = Impeller diameter
- Q = Impeller primary flow (pumping capacity)
- ρ = Fluid density

Before two impellers can be compared, a basis for the comparison must be established. While many combinations of parameters can be applied (e.g., power required at constant flow and speed, or constant speed and diameter), the most applicable to the flow controlled operations of blending, solids suspension, and heat transfer is constant diameter (D) and constant flow (Q). Applying the basic mixing formulae in ratio form enables the comparison.

The performance of different impellers can be evaluated in relation to each other. For example, Table 2 compares the Lightnin A510 with a 45-degree pitched blade turbine. Table 2 demonstrates that at constant impeller diameter to tank diameter ratio (D/T) and constant flow (Q) (i.e., constant process result), the Lightnin A510 mixer requires 51% less power and less than half the torque and therefore lower operating costs than a mixer fitted with a pitch blade turbine.

The CFD shows the improved circulation in the flow pattern developed by the Lightnin A510 compared with a pitch blade turbine. Improved flow circulation can help to reduce blend time and does produce improved solid suspension. Using the Lightnin A510 impeller for these duties will consume less power than a PBT.



PBT A510

Table 2. Comparison of A510 and PBT

PARAMETER	LIGHTNIN A510	PBT
Np	0.3	1.28
Nq	0.56	0.79
Speed, N	1.00	0.71
Diameter, D	Same	Same
Flow, Q	Same	Same
Power, P	1.00	1.51
Flow/Power	1.00	0.66
Torque, T	1.00	2.13

Lightnin Process Consulting Services

SPX and their Lightnin brand have long supported the need of providing full-service mixing support to our valued customers. In today's business environment of "doing more with less," local resources at your operation have been stretched or eliminated. At Lightnin, we recognized this and have increased the level of process support available to our customers. Evaluation and resolution of our customers' mixing issues has been a core strength for many years at Lightnin.

You can leverage the resources and knowledge base of Lightnin by optimizing your mixing processes and solving any mixing problems. Lightnin's Process Technology Lab enables this support to be efficiently executed to minimize your costs. Lightnin will evaluate your existing mixer design and process goals to determine opportunities for improvement.

Lightnin will partner with your technical group to reduce the time and expense for developing new mixer applications. Lightnin can assist in the specification of mixer design, tank internals, feed stream locations, and product draw-off position to optimize your operation. Lightnin has extensive experience in scaling up lab designs and achieving guaranteed full-scale performance.

Lightnin's consulting work starts with a discussion of your needs and process information. Then a proposal is created to define the project scope, responsibilities, deliverables, cost, and schedule. A path forward is then concisely and clearly written and agreed to by both parties. Bidirectional confidentiality agreements are frequently a necessary and common course for doing business.

Support Services

Process

- Solids suspension analysis and optimization
- Mass transfer analysis and optimization
- Blending analysis and optimization
- G/L reaction improvement
- Heat transfer improvement
- Mechanical troubleshooting
- Process troubleshooting
- Process capability development — audit of your mixing systems and report on how to improve
- Scale-up and scale-down expertise

Capabilities

- Lab dedicated fabrication facility
- Solid suspension with particle size distribution measurement
- Mass transfer rates DO measurement
- Flow visualization with dye/pH indicators
- Conductivity probes with high-speed data acquisition for quantitative blending analysis
- High viscosity solution preps
- Fluid force measurements with high-speed data acquisition
- Advanced CFD and FEA modelling

Support Equipment

- Full-scale testing: 15 m x15 m (50 ft by 50 ft)
- Fully instrumented test tanks Ø 2.5 m and Ø 3 m (Ø 8 ft and Ø 10 ft)
- Laboratory testing with acrylic and stainless tanks
- Large impeller inventory
- Torque measurement on mixer shaft
- Digital video recording
- Microtrac particle analyzer
- Auto moisture analyzer
- Laser doppler velocimetry lab
- Solvent rated lab (XP)
- Process tomography (3D conductivity measurements)
- 3D printing for rapid development and production and testing of impeller technologies

When Mixing Matters

MIXING TECHNOLOGY FROM LIGHTNIN

SPX®

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