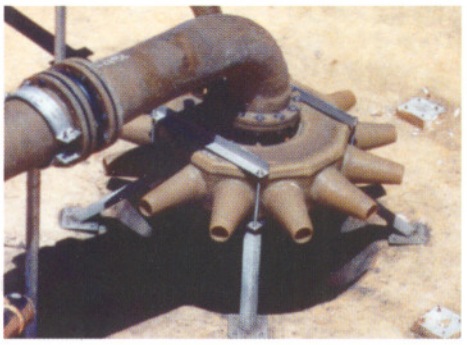
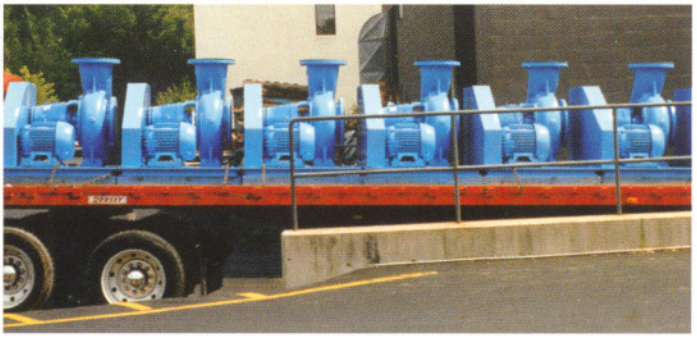
MIXING SYSTEMS, INC.





JET AERATION AND JET MIXING SYSTEMS

Specializing in Pulp and Paper Mills

7058 Corporate Way, Dayton, OH 45459
Phone: 937-435-7227 ♦ Fax: 937-435-9200

Specializing in jet aeration and jet mixing systems that meet the demands of the Pulp and Paper Industry.

Effluent treatment is one of the chief concerns of pulp and paper mills. Pulp mills need to efficiently produce pulp as well as treat the effluent at a reasonable cost.

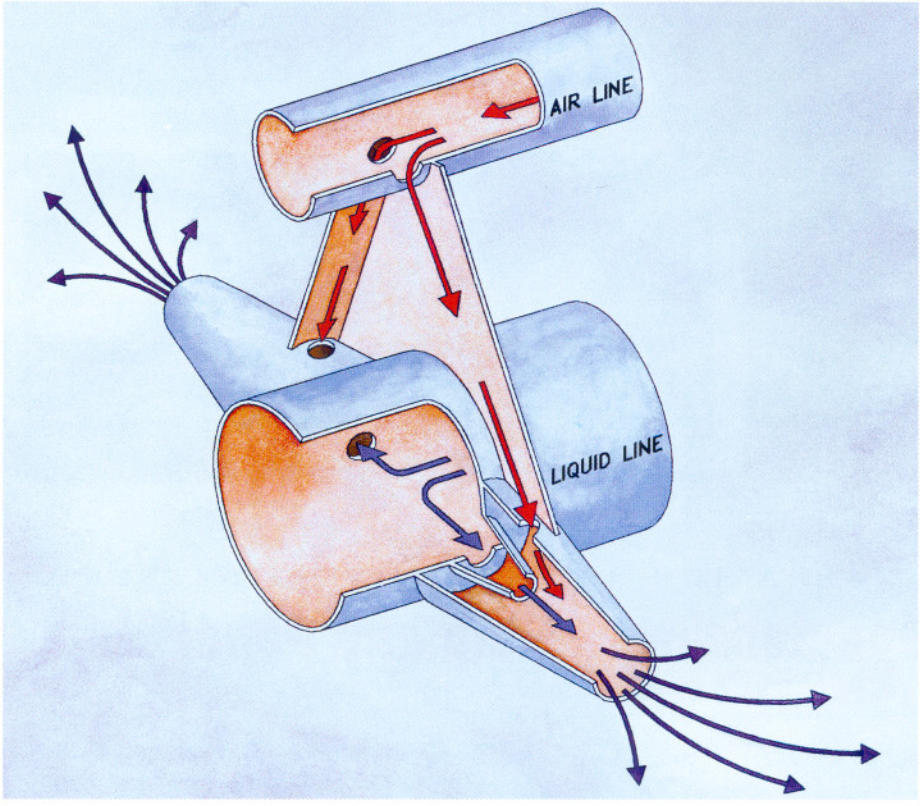
Typical BOD_5 (biochemical oxygen demand) concentrations from pulp mills range from 100 to 5,000 ppm BOD_5. In addition, this wastewater is toxic to fish, low in dissolved oxygen levels, and usually hot. Prior to discharge, wastewater needs to be neutralized, oxygenated and cooled to properly control the organics in the wastewater.

Jet aeration systems use a combination of pumps and blowers to provide efficient oxygen transfer and mixing. Jet aeration systems efficiently treat pulp and paper mill wastewater while requiring little maintenance. For these reasons, jet aerators are often considered the best method of treating wastewater for pulp and paper mills.

PRINCIPLES OF OPERATION

Jet aerators use the ejector method of contacting gases and liquids. The jet consists of a double nozzle arrangement. Each jet has a primary inner nozzle, an intermediate high shear mixing chamber, and an outer secondary nozzle.

Mixed liquor, recirculated from the tank, moves through the primary inner nozzle where it becomes a high velocity, low pressure stream.



Low pressure gas enters the mixing chamber perpendicularly to the high velocity liquid stream. **Intense contacting and mixing** of the two streams occurs in the high shear mixing chamber. The intimate contact between gas and liquid streams results in the formation of **micron-size bubbles**.

The fine bubble gas/liquid mist jets out through the secondary nozzle into the main tank volume. The high velocity plume from the secondary nozzle **travels horizontally**, spreading throughout the tank volume before rising to the surface.

The horizontal travel of the plume maintains high pressure conditions for a longer time than conventional diffused air systems. This high pressure condition gives the gas bubbles a greater opportunity to dissolve in the liquid, **increasing the oxygen transfer efficiency**.

Injection of the plume into the tank volume provides all the necessary mixing energy. The expanding plume's powerful movement creates **fine eddy currents** in the surrounding liquid, thoroughly **mixing** the tank and keeping the MLSS solids in suspension.

High velocity gradients form within the tank volume and enhance mixing and solids suspension. The gradients are of a random nature, insuring the uniformity of the aerated liquid and the thorough suspension of solids.

When the initial horizontal momentum of the plume dissipates, it rises to the top of the liquid surface. This produces an air lift effect that further mixes the tank contents.

The jet plume also creates good molecular dispersion, sending oxygen molecules to microorganisms much faster. Such intimate mixing of reactants assures effective process operation.

ENERGY EFFICIENT

Jet aeration systems use less energy than other diffused aeration systems. In actual wastewater treatment plants, side-by-side comparisons with diffused aeration systems have shown **energy reductions of up to forty percent**. Figures are similar when compared with pure oxygen or mechanical aeration systems.

Jet aerators have replaced low and high speed aerators at several installations. **Lower operating power and lower maintenance costs** have been the reason for all replacements.

HIGH ALPHA FACTOR

Alpha factor is the ratio of the oxygen transfer rate in wastewater to the oxygen transfer rate in clean water. Alpha factor is dependent on the aeration device used and also on the presence of chemicals such as surfactants in the wastewater.

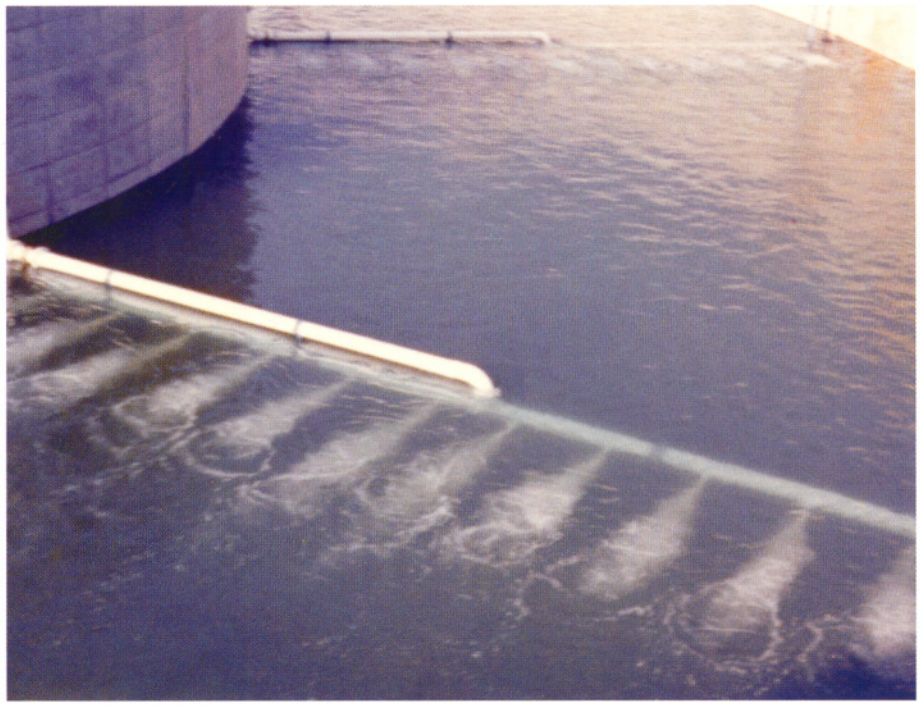
Jet aerators produce a high alpha factor in pulp and paper mill wastes. The high alpha factor is due to the presence of surfactants in pulp and paper wastewater.

Oxygen transfer is enhanced due to the high shear at the gas/liquid interface. Typical alpha factors achieved with various aeration devices are shown below.

Alpha Factor for Various Devices	
Jet Aerators	0.9
Coarse Bubble Diffusers	0.8
Fine Bubble Diffusers (Membrane or ceramic)	0.4
Surface Aerators	0.85

High shear aeration devices such as jet aerators yield a higher alpha factor due to surface renewal at the gas/liquid interface. Low shear aeration devices such as fine bubble diffusers (membrane or ceramic) yield a lower alpha factor because of insufficient renewal (oxygen saturation) at the gas/liquid interface.

All aeration systems are standardized for performance at standard conditions. Therefore, the process oxygen (AOR) is converted to standard oxygen (SOR) and is inversely proportional to the alpha factor. For this reason aeration systems with low alpha factors must be designed for a higher SOR.



Relative Oxygen Required (SOR)	
Jet Aerators	100%
Coarse Bubble Diffusers	112%
Fine Bubble Diffusers (Membrane or ceramic)	225%
Surface Aerators	106%

LOW MAINTENANCE

A jet aeration system by Mixing Systems, Inc. consists of quality components that have an established reputation for reliability.

- Materials of construction are durable and resistant to abrasion, corrosion, and ultra-violet light.
- The jet nozzles used by Mixing Systems, Inc. have no moving parts that can wear out and no small passages to clog.
- Pumps and blowers are normally placed outside the tanks where they can be easily serviced.

In addition, the system is designed and manufactured to minimize field installation labor. Jet assemblies and piping are typically fiberglass which is lightweight, adaptable and easily installed.

NO ICING PROBLEMS

All aeration and mixing occur below the surface so there is no mist or spray problems. In addition, no icing problems occur because the aeration and mixing units eliminate thermal stratification, thus preventing freezing.

DEEP TANK OPERATION

Jet aerators have been used in tanks with 13 to 65 ft (4 to 20 meters) liquid depth. In deep tanks, due to the hydrostatic pressure of the bubbles, the initial and average bubble size is smaller than in shallow tanks. Smaller bubbles result in high mass transfer due to the following reasons.

- Higher surface area in the tank volume.
- The bubble stays in the tank longer due to the lower velocity of the rise.
- Higher pressure in the bubbles produce a greater driving force for oxygen transfer.

Mixing in deep tanks is provided from the bottom of the tank to the top. For this reason, jet aerators are not limited to just shallow tanks. The jet aerators provide maximum mixing near the bottom of the tank.

PROVEN PERFORMANCE

Jet aerators have been used in over one hundred pulp and paper mills. Jet aeration is a prevailing, proven technology that achieves high oxygen transfer efficiencies with minimum maintenance and minimum operator attention.

Jet aeration systems are designed for a twenty year life. These systems are designed so there is no need to drain the tanks for maintenance purposes. The pumps and blowers, which are generally the only components that require maintenance, are placed outside the tanks.

HIGH TOXICITY REMOVAL

Toxicity in wastewater is caused by chemicals such as resin acids. Good mixing in the aeration tank and high BOD_5 removal efficiencies result in a non-toxic effluent.

The raw influent from the primary clarifier can be directly sent through the jet aeration system where it is immediately contacted with oxygen.

This contact of the concentrated influent wastewater prior to release into the aeration tank dilutes the toxins and minimizes the shock loads in the aeration tank. The wastewater is then dispersed through a series of jet aeration nozzles prior to release into the aeration tank.

INDEPENDENT CONTROL

With the jet aeration system, both mixing and oxygen transfer can be independently controlled. Mixing is regulated by the recirculation pump. The level of oxygen transfer is controlled by the amount of air the blower releases to the jet aeration system.

Efficient mixing and oxygen transfer will yield an effluent which is non-toxic. When the wastewater is properly treated, 100% fish survival will occur in 100% effluent.

LOW EFFLUENT AOX LEVELS

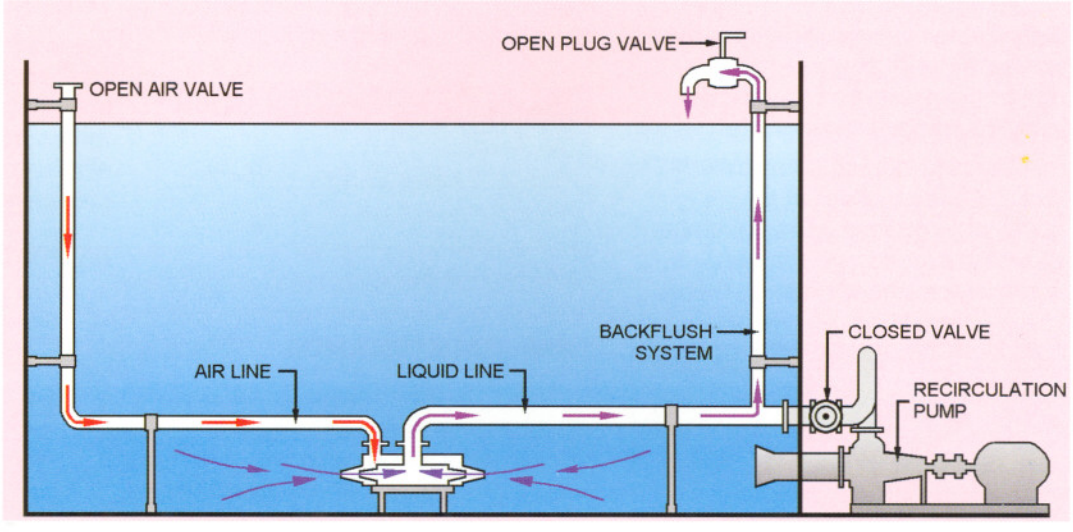
AOX (adsorbable organic halogens) are formed by a chemical reaction from the pulp bleaching processes which use chlorine or chlorine dioxide as bleaching agents. Jet aeration systems produce acceptable AOX levels in the effluent. Efficient mixing results in low AOX effluent.

OPTIONAL BACKFLUSH

A pneumatic backflush system can virtually eliminate all in-basin maintenance and manual cleaning, thereby maintaining high oxygen transfer rates and efficiencies.

By simply shutting off the pump, opening the backflush valve and continuing to supply air to the system, the unit's aerodynamic design converts the submerged aeration system into a pneumatic air lift pump.

In the backflush mode, air flow blows backward through the system, displacing the liquid in the liquid distribution line and pumping the surrounding liquid in the reverse direction through the jets and liquid lines. This cleans the jet nozzles and the submerged aeration system of fouling material and debris. Most plants backflush their aeration tank once each month to maintain maximum efficiency.



PILOT PLANT AVAILABLE

Pilot plant equipment is available from Mixing Systems, Inc. for the following tests.

- Treatablilty studies
- Alpha testing in wastewater
- Testing for solids suspension
- Oxygen transfer testing
- VOC stripping
- AOX removal
- Velocity testing

MILLAR WESTERN PULP, Whitecourt, Alberta

Type of Mill	CTMP pulp mill
Flow, MGD *(M^3/day)*	4 MGD *(15,000 M^3/day)*
Design BOD, lb/day *(kg/day)*	120,000 lb/day *(54,000 kg/day)*
Actual Treated BOD	132,000 lb/day *(60,000 kg/day)*
Process	Activated sludge
Number of Aeration Tanks	One tank, 720 ft x 246 ft *(220 M x 75 M)* at bottom
Total Tank Volume	32 MG *(120,000 M^3)*
Liquid Depth, ft *(M)*	23 ft *(7 M)*
Hydraulic Detention Time	8 days
Number of Aerators/Mixers	Seven aerators
Connected HP	Four 200 HP pumps, three 125 HP pumps, Two 800 HP blowers
Mill Capacity	1,000 tons per day
Start-up Date	1988

Millar Western Pulp was designed to treat 119,000 lb/day *(54,000 kg/day)*. This system was able to achieve a treatment of 60,000 kg/day. These jet aerators are the **largest jet aerators** produced in the world. The aerators have a 36-inch *(900 mm)* liquid line and a 20-inch *(500 mm)* air line. Pumping capacity of each aerator is 28,000 GPM. Air flow handled by each aerator is 8,000 SCFM.

FIBRECO PULP, Taylor, British Columbia

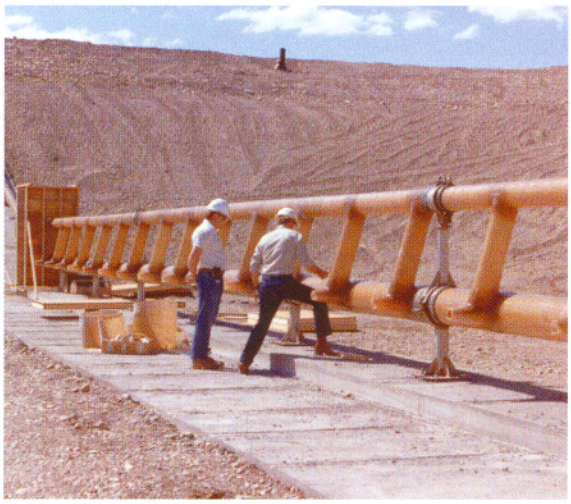
Type of Mill	CTMP mill
Flow, MGD *(M^3/day)*	4 MGD *(16,000 M^3/day)*
Design BOD, lb/day *(kg/day)*	100,000 lb/day *(41,000 kg/day)*
Actual Treated BOD	132,000 lb/day *(60,000 kg/day)*
Process	Activated sludge
Number of Aeration Tanks	One tank, 456 ft x 154 ft *(139 M x 47 M)*
Total Tank Volume	38 MG *(146,000 M^3)*
Liquid Depth, ft *(M)*	33 ft *(10 M)*
Hydraulic Detention Time	8 days
Number of Aerators/Mixers	Twelve aerators, ten mixers
Connected HP	Four 200 HP pumps, two 50 HP pumps, Two 1000 HP blowers
Mill Capacity	1,000 tons per day
Start-up Date	1988

Fibreco Pulp is designed for 95% BOD_5 removal. The effluent from the mill is non-toxic with **100% fish survival in non-diluted effluent.**

CELGAR PULP CO., Castlegar, British Columbia

Type of Mill	Bleached kraft mill
Flow, MGD *(M^3/day)*	17 MGD *(66,000 M^3/day)*
Design BOD, lb/day *(kg/day)*	53,000 lb/day *(24,000 kg/day)*
Process	Activated sludge
Number of Aeration Tanks	One tank, 650 ft x 230 ft *(198 M x 70 M)*
Total Tank Volume	35 MG *(132,000 M^3)*
Liquid Depth, ft *(M)*	33 ft *(10 M)*
Hydraulic Detention Time	2 days
Number of Aerators/Mixers	Four aerators
Connected HP (by others)	Four 150 HP pumps, one 1200 HP blower
Mill Capacity	1,200 tons per day
Start-up Date	1993

The jet aeration system for **Celgar Pulp Company** was selected for **trouble free operation in cold climates**. Temperatures varies from -40° F to 90° F *(-40° C to 32° C)*. The system was consistently able to achieve 98% BOD_5 removal efficiencies.



FLETCHER CHALLENGE, Mackenzie, British Columbia

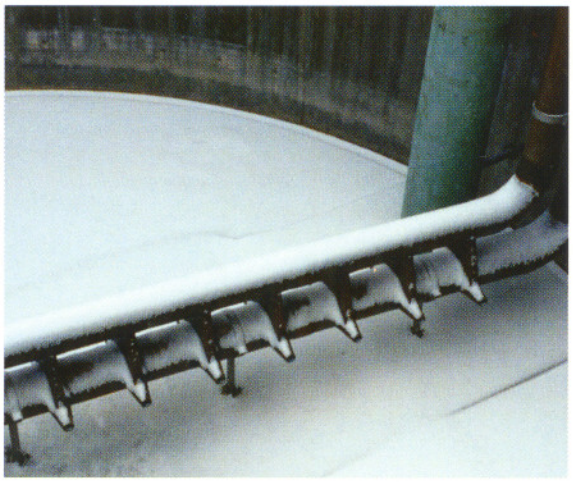
Type of Mill	Kraft pulp mill
Flow, MGD *(M^3/day)*	21 MGD *(80,000 M^3/day)*
Design BOD, lb/day *(kg/day)*	53,000 lb/day *(24,000 kg/day)*
Actual Treated BOD	66,000 lb/day *(30,000 kg/day)*
Process	ASB (two stage)
Number of Aeration Tanks	One irregular shape basin, approximately 680 ft x 450 ft *(207 M x 137 M)* at bottom
Total Tank Volume	98 MG *(370,000 M^3)*
Liquid Depth, ft *(M)*	35 ft *(10.7 M)*
Hydraulic Detention Time	4.6 days
Number of Aerators/Mixers	Four aerators, eight berm mixers
Connected HP	Four 75 HP pumps, four 150 HP blowers
Mill Capacity	600 tons per day
Start-up Date	1989

Fletcher Challenge has jet aerators installed in a 98 MG (370,000 M3) aeration tank to be used as Cell 1. The existing tank with surface aerators is used as Cell 2. Jet aerators achieve 70% BOD_5 removal in Cell 1. Foam in the jet aeration tank is 4 to 6-inches (10 to 15 cm). Foam in the surface aeration tank is 2 to 3 feet (0.6 to 0.9 M) thick. The jet aeration system **produces less foam** in pulp and paper mills.

ST. MARYS PAPER, Sault Ste. Marie, Ontario

Type of Mill	Pulp and paper mill waste
Flow, MGD *(M^3/day)*	6 MGD *(23,000 M^3/day)*
Design BOD, lb/day *(kg/day)*	20,000 lb/day *(9,000 kg/day)*
Process	Activated Sludge
Number of Aeration Tanks	One tank, 130 ft *(40 M)* diameter
Total Tank Volume	3 MG *(12,000 M^3)*
Liquid Depth, ft *(M)*	27 ft *(8.2 M)*
Hydraulic Detention Time	12 hours
Number of Aerators/Mixers	Four aerators
Connected HP (by others)	Four 40 HP pumps, two 200 HP blowers
Mill Capacity	500 tons per day
Start-up Date	1995

St. Marys Paper consists of an anoxic selector tank followed by an activated sludge tank. The purpose of the anoxic selector tank is to **minimize filamentous bacteria**. Jet mixers are used in the anoxic tank and jet aerators are used in the aerobic reactor. The system achieves 98% BOD5 removal.



PINE FALLS PAPER, Pine Falls, Manitoba

Type of Mill	Newsprint pulp de-inked
Flow, MGD *(M^3/day)*	8 MGD *(30,000 M^3/day)*
Design BOD, lb/day *(kg/day)*	66,000 lb/day *(30,000 kg/day)*
Actual Treated BOD	68,000 lb/day *(31,000 kg/day)*
Process	Activated sludge with selector tank
Number of Aeration Tanks	One aeration tank, 200 ft *(61 M)* diameter One selector tank, 54 ft *(16.5 M)* diameter
Total Tank Volume	6.3 MG *(24,000 M^3)*
Liquid Depth, ft *(M)*	26 ft *(8 M)*
Hydraulic Detention Time	19 hours
Number of Aerators/Mixers	Five aerators
Connected HP (by others)	Five 100 HP pumps, four 300 HP blowers
Mill Capacity	360 tons per day
Start-up Date	1995

The activated sludge system for **Pine Falls Paper** consists of an selector tank followed by an aeration tank. The selector tank can be operated in the aerobic or anaerobic mode. The system is achieving **98% BOD_5 removal**.

HARMAC PACIFIC, Nanaimo, British Columbia

Type of Mill	Bleached kraft mill
Total flow, MGD *(M^3/day)*	24 MGD *(91,000 M^3/day)*
Design BOD, lb/day *(kg/day)*	65,000 lb/day *(30,000 kg/day)*
Process	Activated sludge with primary and secondary clarifiers
Number of Aeration Tanks	Two tanks, 180 ft *(55 M)* diameter
Total Tank Volume	12 MG *(47,000 M^3)*
Liquid Depth, ft *(M)*	32 ft *(9.8 M)*
Hydraulic Detention Time	12 hours
Number of Aerators/Mixers	Twelve aerators
Connected HP (by others)	Twelve 60 HP pumps, one 1200 HP blower
Mill Capacity	1,100 tons per day
Start-up Date	1993

Harmac Pacific was designed so the tanks can be run in parallel or in series. Each tank is designed to treat 80% of the BOD5 load with one of the two tanks out of operation.

CONSOLIDATED PAPER, Stevens Point, Wisconsin

	First Installation	Second Installation
Type of Mill	Paper	
Total flow, MGD *(M^3/day)*	9 MGD *(34,000 M^3/day)* **total**	
Design BOD, lb/day *(kg/day)*	45,000 lb/day *(20,400 kg/day)* **total**	
Process	Oxidation ditch	Oxidation ditch
Number of Aeration Tanks	Three ovals, 135 ft *(41 M)* long by 60 ft *(18 M)*	One oval tank, 250 ft x 100 ft *(76 M x 30 M)*
Total Tank Volume	3.5 MG *12,500 M^3)*	4 MG *(15,000 M^3)*
Liquid Depth, ft *(M)*	20 ft *(6 M)*	25 ft *(7.6 M)*
Hydraulic Detention Time	20 hours	20 hours
Number of Aerators/Mixers	Nine aerators (3/tank)	Four aerators
Mill Capacity	750 tons per day	
Start-up Date	1989	1995

Consolidated Paper manufactures pulp and has paper machines. Their system consists of four jet aeration channels (oxidation ditches). This paper mill decided to use jet aerators because the system gives **consistent 98% BOD_5 removal** and **requires very little maintenance**. In addition, the system is suitable for cold climates. System is **suitable for cold climates**. Ambient temperature during winter is 32 to -40° F (0 to -40° C).

INDORAYON, Tapanuli Utara, Indonesia

Type of Mill	Pulp mill waste
Flow, MGD *(M^3/day)*	26 MGD *(100,000 M^3/day)*
Design BOD, lb/day *(kg/day)*	66,000 lb/day *(30,000 kg/day)*
Process	Activated sludge
Number of Aeration Tanks	Two tanks, 295 ft *(90 M)* diameter
Total Tank Volume	34 MG *(127,000 M^3)*
Liquid Depth, ft *(M)*	33 ft *(10 M)*
Hydraulic Detention Time	30 hours
Number of Aerators/Mixers	Eight aerators
Connected HP	Eight 60 HP pumps, five 300 HP blowers
Mill Capacity	900 tons per day
Start-up Date	1995

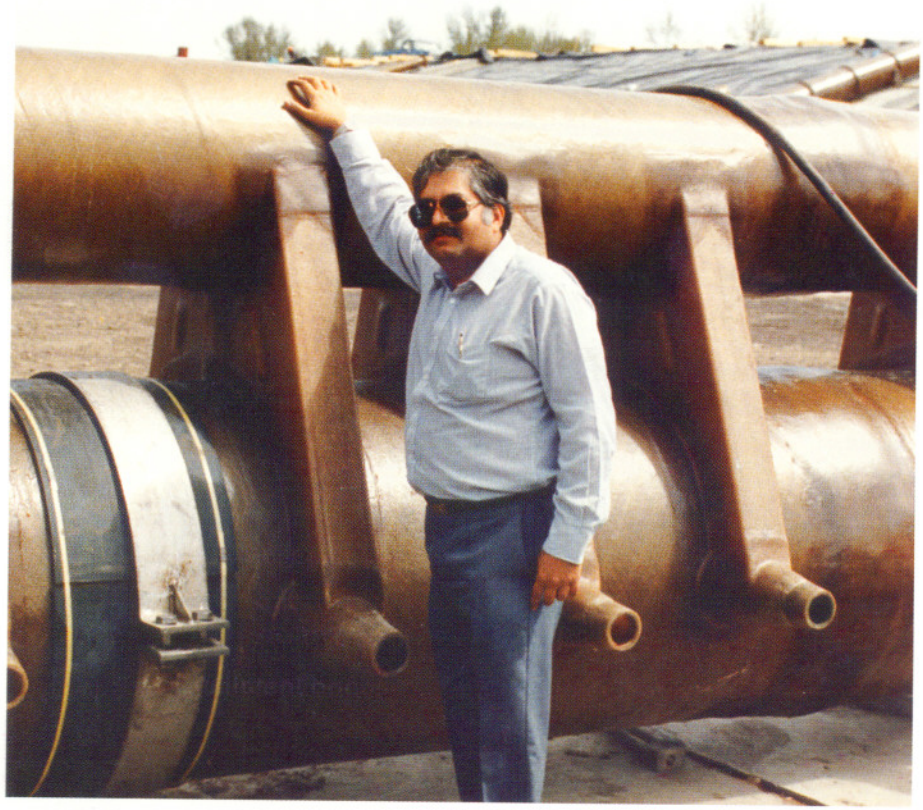
Indorayon is a pulp mill that manufactures 50% pulp and 50% rayon. The pulp and rayon streams are mixed prior to treatment in two activated sludge tanks. This mill considered all available aeration technologies and decided to purchase jet aerators because **jet aerators were considered to be the most cost effective** for the mill.

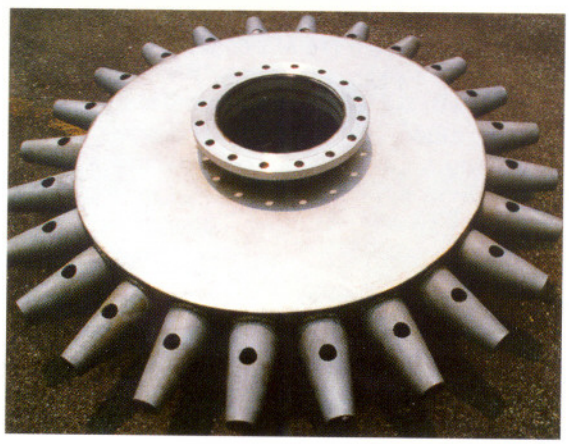
PULP & PAPER INSTALLATIONS

- Appleton Papers
- Celgar Pulp Company
- Consolidated Papers, Inc.
- Fibreco Export Pulp Mill
- Fletcher Challenge
- Georgia Pacific Corporation
- Great Lakes Forest Products
- Harmac Pacific
- Kimberly-Clark Corporation
- Millar Western Pulp Limited
- Pine Falls Paper Company
- Quesnel River Pulp Company
- St. Marys Paper Limited
- Tripap Mill

OTHER INDUSTRIES SERVICED

- Automobile
- Beverage
- Brewery
- Chemical
- Corn Processing
- Food Industries
- Petrochemical
- Pharmaceutical
- Specialty Industries
- Refinery
- Textile





↑ Mixing Systems, Inc. manufactured the world's largest jet aerators. Each aerator consists of a 36-inch liquid line, a 24-inch air line and 124 jet nozzles.

← Mixing Systems, Inc. is continually looking for innovative solutions to meet its customers needs.

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