



## Waterjet Rockets



**T**he University of Rhode Island (URI) student chapter of the American Society of Mechanical Engineers sponsored its second annual Water Rocket Competition to celebrate the last day of classes on May 2, 2000. Competitors included both students and faculty from the URI College of Engineering. Participants engineered aerodynamic features onto two-liter soda bottles, which were then filled with water, pressurized, and shot skyward from the middle of the Quadrangle.

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# Practical Aspects of Hydrodemolition

By Rick Fitzgerald, WOMA Corporation

**H**ydrodemolition is the selective removal of concrete using high-pressure water; selectively removing deteriorated concrete and leaving sound concrete below the intended level of removal. The hydrodemolition process will not damage rebar or cause micro cracks in the concrete, as will mechanical methods such as jackhammers.

It is used where steel is imbedded in concrete and typically used as an alternative to jack hammers. Over the years the hydrodemolition process and equipment has matured. Today the robotic units are capable of performing vertically, horizontally, and overhead as standard units. There are a variety of attachments available allowing removal from the underside of bridge decks, columns, and parapet beams to name a few.

The process is the same no matter what hydrodemolition unit is used. High-pressure water is delivered to the robot through a flexible high-pressure hose. The water travels down a lance where it meets a nozzle. The nozzle orifice is sized according to pressure and flow requirements of the pump. The lance manipulates the jet of water leaving the nozzle. The lance will either oscillate or rotate the waterjet nozzle.

Lance oscillation is where the lance moves forward and backward longitudinally. The lance must also adjust the "angle of attack" to the direction of travel. If the lance is traveling to the right the lance angle is adjusted to the right. As the lance nears the end of its travel to the right it will encounter a sensor; the sensor will tell the system that the lance is ready to move to the left. At this time the



Flatwork on a bridge deck.

lance will begin to move to the left, while at the same time the angle of attack will adjust itself to the left. This combination of oscillation and the angle of attack allows for the removal of concrete from underneath the rebar.

In a rotation system the water travels down the lance and is discharged at a set angle. The angle can be set from 10 - 30 degrees. Depending on the manufacturer the angles will vary. A 10-degree angle would be used for very deep cutting or very hard concrete. This angle would not undercut the re-bar leaving a "shadow" effect. A 30-degree angle would be used for very soft or very shallow cuts. This angle would give the maximum amount of undercut leaving little concrete to be removed with hammers. All hydrodemolition projects will require some jackhammer work.

Hydrodemolition leaves the surface that has been cut with a jagged or craggy surface (profile) much like that of an English muffin that has been separated with a fork rather than with a knife. Many concrete suppliers have commented on the great bonding area left by hydrodemolition. Jackhammers tend to leave a flatter surface. The result is fewer peaks and valleys providing less bonding surface.



Parapet beam attachment.



Wall work.

*Photos illustrate work completed using Aquajet Systems' equipment. Photos provided courtesy of WOMA Corp.*

Once the equipment is at the site it is necessary to do a test cut. The robot is positioned over a section of concrete that is determined to be sound. Generally sounding with a hammer or dragging a chain over the surface determines the soundness of the concrete. The test cut must be done on a section of sound concrete to ensure that all sound concrete encountered by the robot is removed to the required depth. If the waterjet should pass over an area of deteriorated concrete then

(continued on page 20)



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## Gardner Denver Acquires Waterjetting Manufacturers

**G**ardner Denver, Inc., a Quincy, Illinois-based manufacturer of industrial blowers and compressors for industrial applications and pumps for petroleum, industrial and waterjetting markets has reported the recent acquisition of three companies:

**CRS Power Flow, Inc.**, a Houston, Texas-based manufacturer of waterjetting products for 10,000 to 40,000 psi applications, including hand-held control guns, foot-operated control guns, fittings, rigid lances, nozzles, valves, accessories and pump replacement parts. CRS Power Flow is also a supplier of waterblasting hoses and flex-lances.

**Jetting Systems & Accessories, Inc.**, a Houston, Texas-based manufacturer of lancing systems, tube bundle cleaning machines and 10,000 to 40,000 psi specialized cleaning systems for industrial applications, such as ship and power plant cleaning. Jetting Systems' niche market has always been in catering to primarily custom-designed equipment for industrial waterjetting applications.

**Butterworth Jetting Systems**, a Houston, Texas-based manufacturer of pumps and water jetting systems, was acquired by Gardner Denver in April 1999. Butterworth is a highly respected manufacturer of high efficiency waterjetting pumps and accessories for 5,000 to 36,000 psi applications, with well in excess of 8,000 pump units currently in operation worldwide.

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## Safety Committee Solicits Comments On Improvements To Recommended Practices

The WJTA Safety Committee solicits comments regarding improvements to the publication, *Recommended Practices for the Use of Manually Operated High Pressure Waterjetting Equipment*. While the Recommended Practices is reviewed periodically at the biennial conferences of the WaterJet Technology Association, your comments and suggestions for improving the publication are invited and welcome anytime.

Please address your comments and suggestions to: Safety Committee, c/o WJTA, 917 Locust Street, Suite 1100, St. Louis, MO 63101-1413, fax: (314)241-1449, e-mail: [wjta@wjta.org](mailto:wjta@wjta.org), web site: [www.wjta.org](http://www.wjta.org).

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## Hydrodemolition in Germany

Heavy rehabilitation work was recently completed on a parking structure and apartment building in Dortmund, Germany. The concrete was seriously deteriorated to the point it could no longer reliably protect the reinforcement bars.

With more than 10,000 square feet (1,000 square meters) of concrete in need of partial removal, the requirements called for the exposure and cleaning of the reinforcement bars, and the concrete surface was to be profiled in order to accept the new concrete.

The job was attempted using hand-held hammers and chisels that delivered very unsatisfactory results — the work progressed slowly and generated dust.

As a result, it was decided to test a WOMA-ECOTHERM® 500 unit, featuring an operating pressure of 7,250 psi (500 Bar), and a maximum flow rate of 8.7 gpm (33 l/min). The equipment used included a rotating carrier head and an abrasive injector head. Using the rotating carrier the contractor was able to treat 40% of the concrete surface; the remainder was completed using the abrasive injector head.

The job was completed much faster than with the original hammer and chisel method, and by using the abrasive injector, the exposed reinforcement bars were cleaned to St 2.5 surface quality level.

Most importantly for the contractor no additional air compressors were required on site to clean the steel. All work was completed with the WOMA-

ECOTHERM® 500 and corresponding accessories.

On this job the WOMA-ECOTHERM® 500 demonstrated its unique capabilities for rehabilitation, sanitation, and refurbishment of reinforced concrete structures.

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# 11th American Waterjet Conference

August 18-21, 2001

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## First Announcement and Call for Papers

Impressive progress and a fast-growing understanding of the diversified applications of waterjet technology are generating a growing excitement in the industry. New techniques and applications are being developed and current ones are being improved. Waterjet technology, now being used in nearly all types of industry — manufacturing, mining, construction, concrete, stone, aerospace, engineering, process, and medical industries — continues to expand at a rapid pace.

The 11th American Waterjet Conference will focus, from a practical and scientific viewpoint, on the most up-to-date industry advances in waterjetting equipment, techniques, and applications. The areas to be addressed include but are not limited to:

- Abrasives, Water, and the Environment
- Advanced Industrial Applications
- Advances in High Pressure Technology
- Automotive Applications
- Cleaning and Coating Removal
- Components and Systems
- Construction and Non-Manufacturing Applications
- Contractor Applications and Processes
- Demilitarization, including removal of land mines (demining).
- Drilling Applications
- Excavation, Tunneling, and Mining Applications
- High Pressure Equipment and Systems
- Jet Mechanics
- Jet-Material Interaction
- Manufacturing Processes
- Market and Future Needs
- Novel Jets and Applications
- Process Modeling and Control Studies
- Rock Cutting
- Safety, Training, and Environmental Protection

Commercial and academic authors are encouraged to submit titles and abstracts for consideration. To submit an abstract(s), please complete the abstract submission form on page 10, attach a copy of your abstract(s), and forward to the attention of the Conference Coordinator at the Waterjet Technology Association. The deadline date for submission of abstracts is November 1, 2000.

An Abstract Review Committee consisting of four referees, chosen from the Organizing Committee and the International Advisors, will review the abstracts. Authors will be advised by February 19, 2001, regarding the decision of the Abstract Review Committee.

The 11th American Waterjet Conference is organized by the Waterjet Technology Association and is endorsed by the International Society of Water Jet Technology. The Waterjet Technology Association looks forward to providing this forum and to your involvement and participation.

## 2001 WJTA Conference Committee

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For each paper to be submitted for consideration, please complete this form, **attach a copy of the abstract**, and mail or fax to WJTA by November 1, 2000. Authors will be advised by February 19, 2001, regarding the decision of the Abstract Review Committee. Please send this form even if you e-mail your abstract.

#### Paper Information

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Please check the category that best describes the topic of your paper. ☐ Applications ☐ Research ☐ Contractor

Indexing words (Check the boxes under the different categories that apply to your paper):

#### Type of Study

- ☐ Modeling (theoretical)
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- ☐ Contractor case study
- ☐ Manufacturing case study
- ☐ Software development
- ☐ Economic analysis
- ☐ Legal
- ☐ Other \_\_\_\_\_

#### Process

- ☐ Cutting
- ☐ Drilling
- ☐ Surface preparation
- ☐ Cleaning
- ☐ Stripping
- ☐ Safety
- ☐ Milling
- ☐ Jet-assisted
- ☐ Other \_\_\_\_\_

#### Related Industry

- ☐ Generic
- ☐ Shipyard
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- ☐ Oil/Gas/Refinery
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- ☐ Waterjet
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- ☐ Cavitation
- ☐ Polymer Jets
- ☐ Other \_\_\_\_\_

#### Material

- ☐ Metal
- ☐ Rock
- ☐ Glass
- ☐ Ceramic
- ☐ Composite
- ☐ Concrete
- ☐ Other \_\_\_\_\_



#### Environment

- ☐ Field work
- ☐ Factory work
- ☐ Submerged
- ☐ Nuclear
- ☐ Demilitarization
- ☐ Offshore
- ☐ Other \_\_\_\_\_

\*August 18 is reserved for the Waterjet "Short Course," safety seminar, and Conference Welcoming Reception.

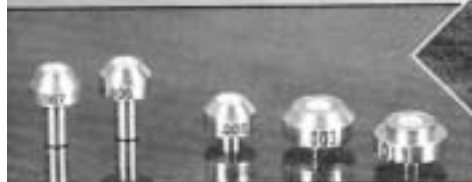
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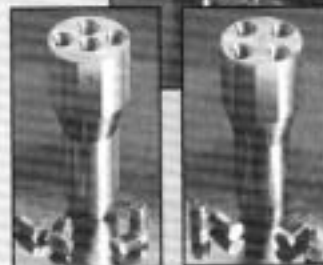
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# Waterjet-Cut Sculpture Dedicated

A public dedication ceremony for the "Millennium Arch" sculpture at the University of Missouri-Rolla (UMR) was held on May 13, 2000, on the grounds of UMR's Castleman Hall, 10<sup>th</sup> and State Streets, Rolla, Missouri.

The 15-foot granite structure, which weighs about 60 tons, was cut and polished at UMR's High-Pressure Waterjet Laboratory in the Rock Mechanics and Explosives Research Center.

Dr. David Summers, Director of UMR's High-Pressure Waterjet Laboratory, and his staff worked with British-born artist Edwina Sandys to create the sculpture.

The Millennium Arch consists of five integral pieces of Missouri granite:

- The arch itself is 15 feet tall and made of two upright stones joined across the top by a lintel.
- Two symbolic figures of a man and a woman, cut out of the upright stones of the Millennium Arch, and polished, stand free of the rough-hewn blocks that had previously constrained them.

Castleman Hall was selected as the site for the sculpture and plaza because of its location on the edge of campus. Because the site is near residence halls, students will pass by the sculpture frequently. It also will serve as a gateway between the campus and the community.

The structure is the second campus landmark to be created on the UMR campus using waterjet technology. The first landmark is a half-scale replica of the ancient Stonehenge of England's Salisbury Plains.



The Millennium Arch. Putting the sculpture in place on the UMR Campus.



The Millennium Arch (sculpture in place).

Stonehenge stands on the northwest corner of the UMR campus.

The Millennium Arch is the brainchild of Sandys, who used sections of the Berlin Wall to create the "Breakthrough" sculpture on the Campus of Westminster College in Fulton, Missouri, about eight years ago. Sandys is the granddaughter of former British Prime Minister Winston Churchill.

Sandys, who now makes her home in New York, chose to sculpt granite from Missouri Red Quarries near Ironton, Missouri.

Millennium Arch is funded through a gift from Scott T. Porter of Granada Hills, California, who received a bachelor of science degree in physics from UMR (then known as the University of Missouri School of Mine and Metallurgy) in 1955.

At the May 13 ceremony, the sculpture was dedicated as a memoria to Porter's parents, as well as to his late wife, Barbara I. Porter.

Porter is the vice president and general manager of a manufacturer of high-powered solid-state radio frequency amplifiers based in Marina Del Rey, California.

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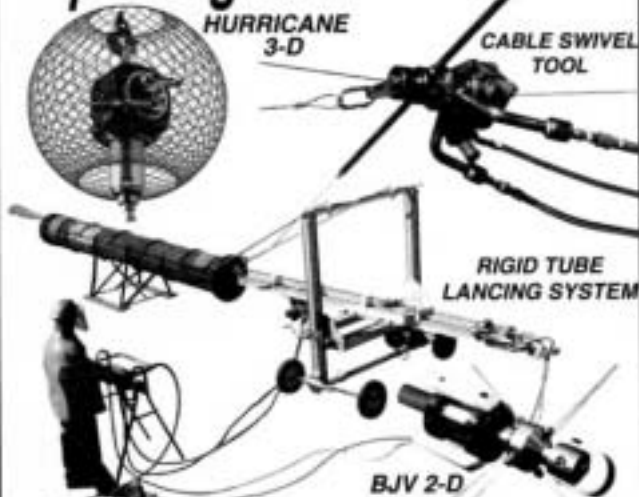
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## ESAB Introduces New Pedestal Rail Waterjet Cutting System

**E**SAB Cutting Systems introduces a new Pedestal Rail model to its line of HydroCut waterjet cutting machines. Similar to its High Rail and Low Rail models, ESAB's new entry-level waterjet system combines the efficiency and versatility of waterjet cutting with ESAB's proven gantry design to offer outstanding versatility and accuracy at an affordable price.

The HydroCut-Pedestal Rail is a dual side drive, gantry-style waterjet cutting system, incorporating the rugged design and construction features associated with ESAB gantry technology, including a sturdy box-beam design; welded, stress-relieved components; and precision-machined contact surfaces for reliable operation. A planetary drive system powered by AC brushless motors, with rotary encoders and ball screws on the x- and y-drives, provides accurate motion and



positioning, with accuracy within  $\pm .005$  inch and repeatability within  $\pm .001$  inch. Cutting speeds range from .01 to 1000 ipm. The Hydrocut-PR offers 4' x 4', 5' x 10' or 6' x 12' cutting configurations.

Hydrocut features a waterjet cutting head rated for up to 60,000 psi (4,137 bar), with orifice sizes ranging from .003 to .022 inch and nozzle sizes from .020 to .065 inch (.518 to 1.65 mm) interior diameter. This flexibility allows HydroCut to handle everything

from small, intricate cuts to thick cuts requiring higher abrasive and water flow rates. The orifice and long-life nozzle are designed to maintain a consistent tool center point for the cutting stream. ESAB's abrasive cutting nozzle provides maximum cutting speeds with reduced operating costs and extremely simple maintenance. The pre-aligned cartridge body, orifice and focusing tube produce a sharp and coherent water-abrasive stream that cuts faster than other nozzles while consuming less abrasive. The pre-aligned components require no tools for installation, are easily installed in seconds and maintain proper centering when replaced.

ESAB's waterjet system features an ultra-high pressure intensity pump with continuous output pressure up to 60,000 psi. ESAB pumps provide flow

(continued on page 23)

## 6th Pacific Rim International Conference on Water Jetting Technology

Sydney, Australia 9-11 October 2000

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Abrasive recycling can be fully automated: the WARD removes abrasive from the waterjet tank, recycles it and, with the optional transport system, returns recycled abrasive to a hopper.

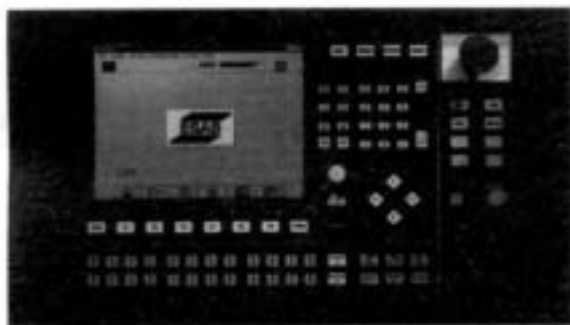
WARDS have been in operation in the United States for over 12 months.

Recycling dispensers are working on ESAB, FLOW, INGERSOLL RAND, JET EDGE, OMAX, PAR and ROMEO waterjets.

The WARD is compact: 5' x 5' x 8' (1.5m x 1.5m x 2.4m).






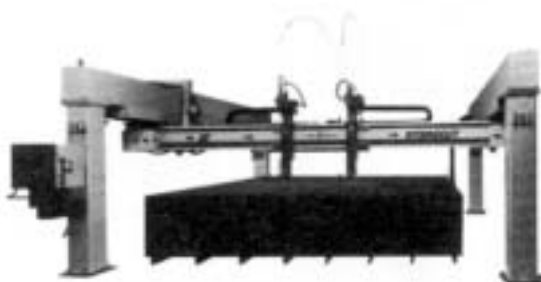
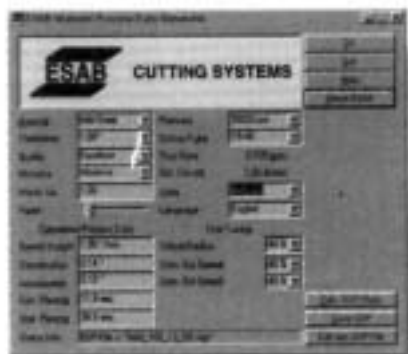


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*Rugged gantry design and AC brushless digital motors on ESAB's HydroCut provide precise motion control and positioning accuracy.*

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## Hydrodemolition In Switzerland

The Northern lane of an 8 km long section of the Highway A2 that guides drivers to the famous St. Gotthard tunnel for traveling through the Alps Mountains was under extensive renovation from March 1 until June 26, 1997. Many parts of this road are protected from avalanches by galleries. The gallery roofs are supported by conical, heavily reinforced concrete pillars located on the right side of the road in direction to the tunnel entry. These pillars are placed on a long horizontal concrete platform. The left side of the Northern lane is bounded by the mountain walls, which are supported by steel anchors and a concrete cover reinforced by wire grids. All of these constructions needed urgent maintenance because they were damaged by wear, chloride attack and corrosion.

A very tough part was a 700 m long road section that covers three galleries and a bridge. The three galleries contain 111 reinforced pillars, each with a cross-section of 50 x 60 cm. The compressive strength of the concrete was about 50 MPa. From these pillars concrete layers of a thickness between 2.5 cm and 6 cm needed to be removed up to a height of 3 m. The space between and behind the pillars was very limited and access restricted by sheer rock walls and precipices. For the removal of the concrete an Aqua Cutter Hydrodemolition Robot HV-550 and a PP-480 power pack were used. The robot operates fully automatic on all sides of the pillars by computer controlled movement of the power head on the standard vertical mast assembly, removing the concrete to a pre set depth without creating any harm to the remaining structure. (For more information, see <http://www.aquajet.se>). The reinforcement was cleared by the waterjet. After the casting of the new concrete was

completed, the pillars were wrapped by special steel plates in a height of 1.5 meters from the ground, for corrosion protection.

Additionally, 150 m of the horizontal platform that supports the pillars was treated in order to remove the concrete that covers the reinforcement bars. Concrete was just partially removed at locations where reinforcement bars were damaged by chloride attack. The removal depth was about 2 cm. Part of this job was also done by using hand-held waterjet tools.

From the left side wall a complete area of 1,200 m<sup>2</sup> concrete was removed by Aqua Cutter hydrodemolition robots, in a pre-set quality depth to secure removal of all deteriorated parts of the construction. Later, this area was sealed by flat coats and a top sealing. Additionally, small horizontal niches were cut into the concrete walls by waterjetting for hosting additional supply pipes and cables. The concrete beds of the rock supporting steel anchors have also been removed by hydrodemolition since the anchors needed to be strengthened.

The bridge in this road section

consisted of two parts. There was a separation allowing the two sections to move independently. After the construction work had subsided and movement of the decks caused by traffic and other external forces was minimized, a decision was made to go with a rigid connection. In order to do this it was necessary to remove concrete from both sides of the parting line to a depth of up to 50 cm using hydrodemolition. In areas not sensitive to surrounding structural damage conventional removal methods such as roto-milling and jackhammers were used to remove a portion of the

(continued on page 24)

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## WOMA Corporation And Hydro-Engineering Sign Distributorship Agreement For Gulf Coast Market

**W**OMA Corporation of Edison, New Jersey and Hydro-Engineering, Inc. of Houston, Texas, announce their decision to jointly bring WOMA water blasting products to the Gulf Coast.

WOMA Corporation, a wholly owned subsidiary of WOMA Apparatebau GmbH, has been successfully supplying WOMA high pressure pumps and accessories to the US market since 1969. The WOMA line of water blasting equipment is one of the largest in the industry with pumps ranging from 25 - 600 hp, pressure ranges from 2,000 to 43,500 psi, and a full complement of tools and accessories.

Hydro-Engineering, Inc., owned by Darrell R. Saha, president, has just acquired new offices at 14706 Park Alameda in Houston, Texas. The new facility, on one acre of fenced-in and zoned land has 5,600 square feet of office and shop space where the equipment will be fabricated and assembled. The company has divided

its efforts into four independently operated divisions: Hydro-Manufacturing, Hydro-Consulting, Hydro-Sales and Service, and Hydro-Rental & Leasing to better serve customer needs. To bring about a true standard of American design to the WOMA line, Hydro-Engineering, Inc. is further charged with the exclusive right to fabricate and assemble all waterjet units and automated accessories destined for the US marketplace. To ensure WOMA's consistent high standards in manufacturing quality control, WOMA has placed a few key employees at the Hydro-Engineering facility.

Hydro-Engineering, Inc. will have exclusive distributorship rights of WOMA equipment for the Gulf Coast states and will house WOMA spare parts, accessories and demo equipment to ensure that customer needs are met.

For more information, visit WOMA's web site at [womacorp.com](http://womacorp.com) or call (800)258-5530.

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## The Bengal ST: A Lower Cost Abrasive Waterjet Machine

**F**low International Corporation introduced the Bengal ST abrasive waterjet machine at the International Machine Tool Show (IMTS) 2000, September 6-13 in Chicago.

The Bengal ST, which will initially be available in a 4' x 4' (1.2 meter x 1.2 meter) size, is designed to be a low-cost version of Flow's BENGAL waterjet cutting machine. This new line of machine tools contains many of the same features and capabilities and are built to the same standards of precision as all Flow products.

The new Bengal ST will include the award-winning PASER 3 abrasivejet system, a choice of Flow's industry-leading ultrahigh-pressure pumps with operating pressures of 40,000 psi, 50,000 psi, or 60,000 psi, and FlowMaster 4.0, the latest generation of Flow's FlowMaster PC-based control software. FlowMaster 4.0 offers users advanced capabilities such as plate alignment, compatibility with a wide range of CAD file formats such as DXF, IGES, CDL, and HPL, built-in part/job costing modules, and Flow's proprietary corner strategy technology (CST), a first in the waterjet industry. CST allows abrasive waterjet users to have complete control over the finished quality of parts coming off their machines by optimizing corners and ensuring that no matter what speed is selected, the part's corners are perfect each time.

"The Bengal ST gives job shop owners a more affordable way to enter the waterjet business," says Michael Ruppenthal, director of marketing at Flow International. "In the past, some waterjets

have been cost-prohibitive to smaller shops just starting out. The Bengal ST provides much of the same leading edge technology as our other machines, yet gives new owners just opening their businesses an option to help contain costs."

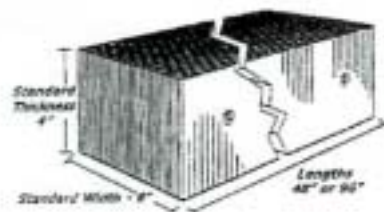
Flow International's ultrahigh-pressure waterjet shapecutting systems are quickly becoming the global "machine technology of choice" for many applications. Flow

International's abrasive waterjet cutting systems are ideally suited for cutting tough and lucrative materials such as titanium, Inconel, brass, steel, aluminum, glass, stone, composites, and other materials from 1/16 inch to 10 inches thick with accuracies between +/- 0.003 to +/- 0.010 inch.

For more information, visit Flow's web site: [flowcorp.com](http://flowcorp.com) or call (253)850-3500.

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## Abrasive Recycling System Demonstrated

EasiJet, Inc. hosted a live demonstration of the Waterjet Abrasive Recycling Dispenser (WARD), an integrated abrasive removal and recycling system, at two companies in the Detroit area in May 2000. Representatives from Jet Edge, Ingersoll Rand, ESAB and PAR attended. The first tour featured a one-year-old WARD. Attendees were given the opportunity to talk to operators and verify the production, recovery and cutting parameters of the recycled abrasive. The new WARD production model was presented during the second tour. This new system is fully automated (PLC), self contained, programmable and is capable of drying approximately 3,000 - 4,000 pounds of good abrasive per day.

During a three-day open house and introduction of the WARD in Zurich, Switzerland in June 2000 the system was appraised by many attendees from throughout Europe. A similar open house for waterjet manufacturers in the US was met with the same enthusiasm with several orders being placed in the US and Europe. The WARD allows waterjet users to recycle abrasive used in the cutting process, with a bottom line savings of up to 40% in total operating cost, including capital repayment.

For more information, visit EasiJet's web site: [www.easijet.com](http://www.easijet.com) or call (330)633-7698.

## Waterjets Cut Granite In Sardinia

The NED-Jet 2000 Quarry Cutting System, manufactured by NED Corporation of Worcester, Massachusetts, is now being used in Salvatore Fiore's quarry, S'Istria on the outskirts of Budduso, Sardinia, Italy. The NED-Jet 2000 uses a 36,000 psi, 7 gpm waterjet to cut slots in granite 15 feet deep, 1.75 to 3 inches wide, and 20 feet or more in length. The system is completely automated.

The NED-Jet 2000 Quarry Cutting System has been used in granite quarries in Massachusetts, North Carolina, South Dakota, California and Texas. Pellegrini Meccanica, Verona, Italy, has a licensing agreement to manufacture and sell NED-Jet cutting systems in Europe.

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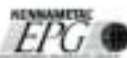
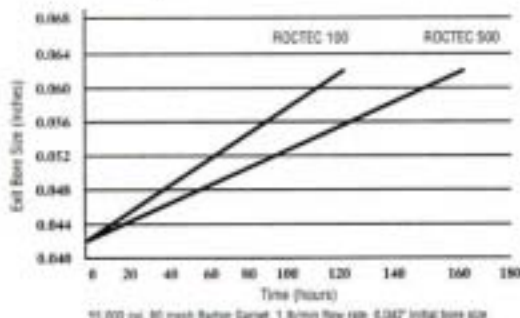
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# Hydrodemolition In Sweden

The Swedish infrastructure is presently in a rehabilitation and expansion process. Repair of roads, bridges and tunnels is continuing on almost every Swedish highway and main road.

One of the major highways in Sweden is the E20. It crosses Sweden in an east-west direction and connects Stockholm and Göteborg. Many of the bridges on this highway have already been refurbished and reinforced. The work has included pillars, sidebeams, expansion joints and bridge decks.

One of the latest projects was to renovate the Jeriko Tunnel. This is a twin tunnel with two lanes in each direction, located outside Göteborg.

The 250 meter tunnel is through rock with concrete reinforcing and sealing at each end and on the walls and ceiling.

The task was to remove the deteriorated concrete from the vertical walls to a depth of approximately 100mm to expose the rebars up to a height of 2.5 meters from the road level. On the curved ceiling selective removal of the deteriorated concrete was required to depths varying from 10 to 120mm.

Hydrodemolition was selected as the removal method for three reasons:

1. To ensure all deteriorated concrete was removed and only the sound parts left;
2. To ensure correct bonding for the new concrete on walls and ceiling;
3. To leave the remaining concrete intact without cracks and without loose rebars.

The tunnel ceiling is curved, starting from about 3 meters up from the ground on the vertical sides and up to a maximum height of 6.2 meters in the middle.

The hydrodemolition contractor used an Aqua Cutter HV-450 and a PP-480 power pack. The HV-450 was equipped with 6 meters of vertical extension masts to reach the top of the ceiling.

The time schedule for this repair was very tight. Work had to be completed prior to the Athletic World Championship in Göteborg. Approximately 2 weeks were available for the concrete removal work of the total area (about 500 square meters in the four tunnels' openings). No time was available for building scaffolding, only small mobile man lifts were available on the job site.

The versatility of the HV-450 allowed the contractor to operate the machine on the road surface and reach all areas. The vertical walls were taken out by placing the Aqua Cutter HV-450 with the power head front against the wall and let it operate vertically on the mast to "dig" out 100mm of concrete and expose the rebars.

The curved ceiling was reached by using the mast extensions and tilting the power head at appropriate angles and then driving the machine on the road along the tunnel.

The hydrodemolition work was finished after only 10 days including mobilization and demobilization.

The concrete was replaced using formwork on the vertical parts and by shot-crete on the curved ceiling.

After finishing the concrete repair, the whole tunnel face was covered by structural painted aluminum sheets.

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## Practical Aspects of Hydrodemolition, from page 2

the concrete will be removed to a depth where the waterjet finds sound concrete.

The depth of the cut is controlled by the amount of time it takes the lance to traverse from side-to-side. The slower the traverse the deeper the cut will be. The pressure and flow rate remain constant throughout the six foot traverse. Once the traverse time is determined it is necessary to set the advancement (forward movement) of the robot. If one pass of the lance cuts a 1 1/2" swath, the advancement should be about 1 1/4". This will allow for a slight overlap to ensure strips of uncut concrete are not left.

Most robots allow an operator to set the number of traverses the lance will make before the robot advances. If the traverse time is 20 seconds to reach the required depth it is best to make multiple traverses. It would be better to make four passes of five seconds each rather than to make one 20 second pass. Multiple passes will give a better cut. The concrete may have slight variations in consistency or a large piece of aggregate that may not be removed on one slow pass. Once the four passes have been completed the robot will automatically move ahead the pre-set distance. A PLC (Programmable Logical Computer) is one of many ways to control the different functions. As the lance passes by a sensor (Electrical Proximity Switch) the PLC will keep count. On the fourth pass the PLC will allow the robot to move.

At this point the operator will monitor the robot and make any minor adjustments to traverse speed forward advancement that might be necessary to obtain the proper depth and quality of cut. The operator will also have time to do things such as pull the 200 plus feet of high-pressure hose along with the robot, keep the robot going straight, check fuel and water levels,

clean or have cleaned the next area to be cut, and anything else that will keep the work moving.

Once an area has been completed it is time for a final clean up. Any number of methods can be used. Vacuum trucks, power sweepers, or fire hose wash downs will take care of the bulk of material. What remains is a mix of granular material and slurry. It is best to clean the slurry while it is still wet and loose from the hydrodemolition process. If it is left in the sun for any period of time it begins to set up and it takes a great deal more effort to clean it. Generally a high-pressure wash down (7,000-10,000 psi) is used to clean the slurry. It is very important to have the surface as clean as possible. The valleys can trap material creating a void or an area where there is no bonding. Contractors pay close attention to this.

A typical bridge deck hydrodemolition unit will work a 200 linear foot section in front and to the rear of the pump unit. This 400-foot section is left to the hydrodemolition work. After this section is completed and the hydrodemolition unit is moved to the next section a crew comes in to clean the completed area and prepare for the pour back. By the time the hydrodemolition is on its third section a pour will begin in the first area. This process continues for the length of the deck.

WOMA Corporation, the exclusive AQUAJET SYSTEMS AB distributor, will conduct live hydrodemolition demonstrations at their location in Edison, New Jersey. If you are interested in attending a demonstration you can contact us at (800)258-5530 or email us at [womacorp@bellatlantic.net](mailto:womacorp@bellatlantic.net).



A wall in which concrete around rebar has been removed.



Circular powerhead on bridge deck columns.



Overhead work on a curved ceiling in a tunnel.

*Photos illustrate work completed using Aquajet Systems' equipment.*

*Photos provided courtesy of WOMA Corp.*



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## Waterjet Surface Preparation

A new brochure from NLB Corporation documents the performance of high-pressure and ultra-high pressure waterjet equipment in surface preparation applications and environmental and economic benefits.

The brochure demonstrates how high-pressure and ultra-high pressure waterjetting (up to 40,000 psi, or 2,800 bar) can produce an exceptionally clean surface without the grit and dust of sandblasting. This improves efficiency and maximizes operator comfort and safety. Graphs and illustrations, with photographs of painted surfaces before and after waterjetting, show the results that can be achieved.

The new brochure also introduces NLB's new HydroPrep™ system, which quickly removes coatings, rust and other tough adherents from large, vertical metal or concrete surfaces. The system features vacuum recovery for wastewater and debris. Users have an option of automated surface preparation, using the SRT-10 Crawler, or manual surface preparation with the handheld VertaJet™ SRT-6.

NLB's VORTEX™ floor and deck cleaners are featured in the brochure, along with other popular NLB accessories. Another highlight is NLB's range of ULTRA-CLEAN® pumps, which are available as electric or diesel units. The models have flows from 1 to 10 gpm (3.8-38 lpm) and engines with 30-250 hp (22-186 kw).

NLB manufactures a full line of quality waterjetting systems and accessories for many uses. These include surface preparation, tank cleaning, descaling, concrete demolition, paint booth cleaning, concrete and pipe cutting, and more.

For more information, visit NLB's web site: [nlbcorp.com](http://nlbcorp.com) or call (248)624-5555.



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## Waterjet Mosaics

Waterjetters arriving at Minneapolis/St. Paul International Airport for the 11<sup>th</sup> American Waterjet Conference, August 18-21, 2001, will see three new mosaics in the floor of the main thoroughfare of the airport. The mosaics, shown in Figures 1, 2 and 3, were cut using waterjet technology.



**Figure 1.**  
*Plant/  
Animal  
Season.* This  
mosaic  
celebrates  
Minnesota  
wildlife.

Photo courtesy of  
Architectural  
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**Figure 2.**  
*The North  
Star.* This  
mosaic  
refers to  
Minnesota's  
status as  
the "North  
Star  
State."

Photo  
courtesy of  
Architectural  
Alliance



**Figure 3.**  
*Minnesota  
Compass  
Rose.* This  
mosaic, set  
with a  
Northern  
red oak  
leaf, orien-  
tates the  
traveler.

Photo courtesy of  
Architectural  
Alliance

A large, dark, vertical image showing a waterjet cutting process. The word 'BARTON' is in large, bold, red letters at the top, with 'WATERJET ABRASIVES' in smaller yellow letters below it. At the bottom, there is contact information in yellow text.

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## ESAB Introduces New Pedestal Rail Waterjet Cutting System, from page 12

rates as high as 2.9 gpm to accommodate cutting orifices as large as .022 inch. The axial piston, variable displacement pumps are available in 30-200 HP models. All incorporate pressure compensation features to deliver a smooth, non-pulsating flow over the complete UHP range. Pumps are constructed on a rugged, all-steel welded framework and sound insulated for quiet operation. High efficiency, totally enclosed, fan cooled (TEFC) electric motors ensure peak efficiency and long service life.

Full process and motion control are provided by ESAB's Vision PC CNC control. ESAB software for waterjet cutting includes features such as pump pressure setting, abrasive feed setting, multiple acceleration setting, programmed kerf offset, 3D CAD software for cutting contours, a real-time cut path display, graphics-to-text editor, on-screen zoom, nesting, plate remnant storage and multi-tasking capabilities.

For more information on the new HydroCut-PR waterjet cutting system, visit ESAB's web site: [www.esab.com](http://www.esab.com) or call 843-664-4394.



## Hydrodemolition In Switzerland, from page 14

concrete. As the conventional removal methods reached areas of sensitivity hydrodemolition robots were used exclusively. This was done because the hydrodemolition process is a vibration free, selective removal method, which will not damage the remaining structure.

The water consumed by hydrodemolition units was pumped up directly from the river, it was collected after use and guided to a water treatment device where it was cleared and pH neutralized before it was released back to the river again.

Concrete was replaced by the wet shotcrete method and by cast in situ method.

A total of five Aqua Cutter hydrodemolition robots of different models were in action at the same time. The robots were powered by various high pressure power packs up to 600 Hp. In addition several high pressure waterjets were in operation with hand held guns for trimming and surface preparation.

This first phase of the giant project could be finished in the short time limit due to the contractor's experience and the high quality and efficiency of all equipment used on site. Additional traffic problems in this important link to Southern Europe could be avoided.

In the Swiss construction industry, where a very experienced and well organized hydrodemolition community is installed, many Aqua Cutter robots and high pressure power packs, of various models, are permanently under contract on heavy concrete rehabilitation projects.

Also several very flexible WOMA high pressure and ultra-high pressure systems, including "Ecomaster" and "Twin Jet" for surface preparation, are very widely used in Switzerland (for more information, see <http://www.woma.de>).

All hydrodemolition equipment from Aquajet Systems AB was supplied by Birchmeier-Atümat AG in 5444 Künten, Switzerland.

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