WJTA Jet News

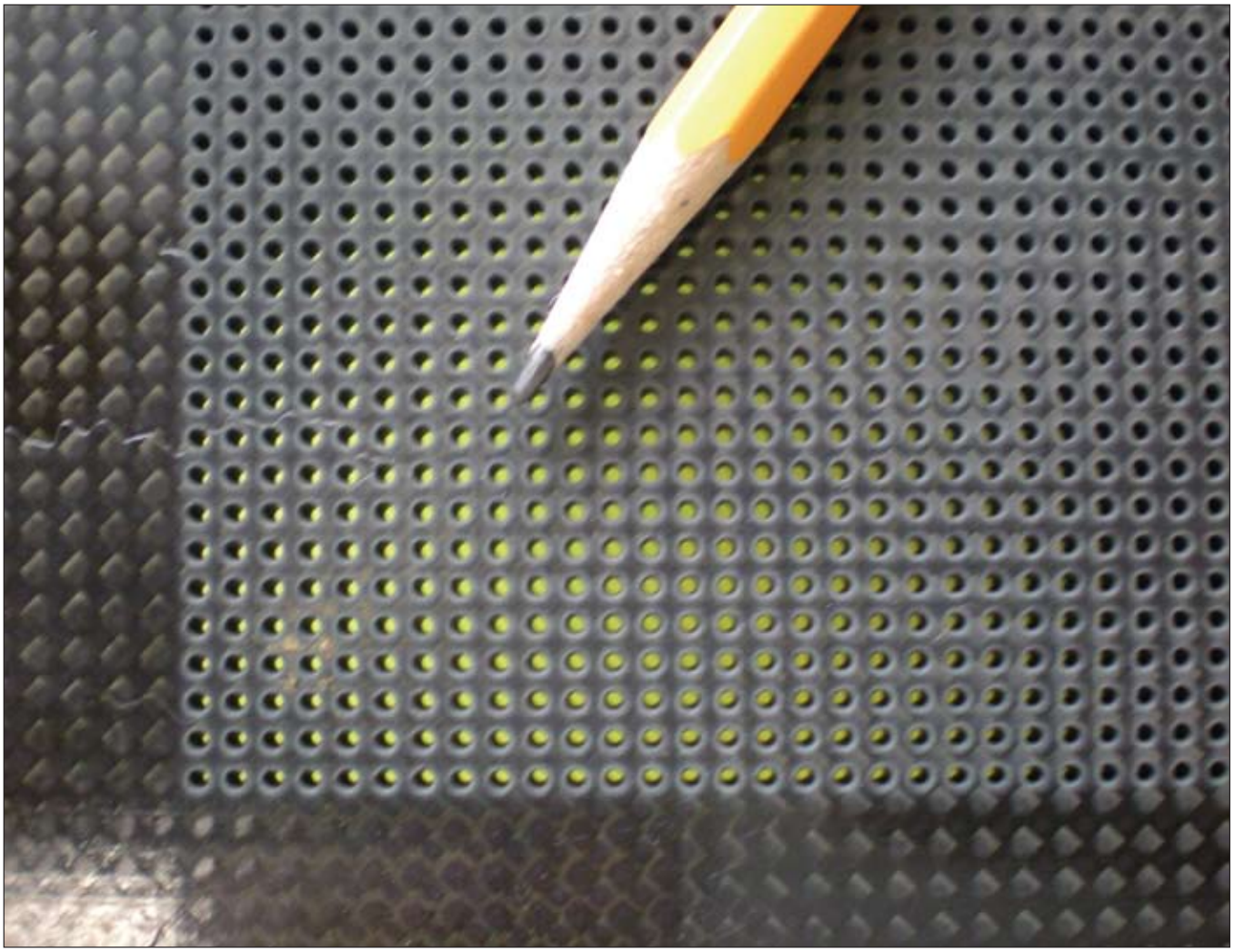
WaterJet Technology Association

DECEMBER 2008

*Published by the WaterJet Technology Association for the benefit of its members*

906 Olive Street, Suite 1200 ● St. Louis, MO 63101-1448, USA ● Telephone: (314)241-1445, Fax: (314)241-1449

# Abrasive-Waterjet Machining Of Composites



**AWJ-drilled holes in a carbon fiber composite panel.**

*See article by Mohamed Hashish, Ph.D., on page 2*

2009 American WJTA Conference and Expo, *Details inside*

August 18-20, 2009 ● Houston, Texas, USA

# Abrasive-Waterjet Machining Of Composites, from page 1

**By Mohamed Hashish, Ph.D., Member – WJTA, Flow International Corporation, Kent, Washington 98032**


## ABSTRACT

The use of carbon fiber composites is significantly increasing as a structural material for commercial airframes. This material represents 50% by weight for the new Boeing 787 and Airbus 350XWB frames. The Abrasive-Waterjet (AWJ) has been the tool of choice for trimming and shapecutting this material due to many technical, environmental, and economical reasons. The AWJ cuts are of acceptable surface finish and of high integrity. The cutting rates are faster than conventional routing. Significant advances have been made in the hardware, software, and the AWJ process reliability, flexibility, and productivity placing the AWJ process as a mainstream tool for airframe manufacturers and their subcontractors.


## 1. INTRODUCTION

The use of advanced materials such as composites has been escalating rapidly over the past three decades, especially in the aerospace industry, coincident with the introduction of AWJ technology to the marketplace in the 1980s. In fact, the use of waterjet technology in aerospace applications has a significant impact on its advance in meeting reliability, flexibility, and productivity demands. This article briefly discusses the AWJ hardware, software, and routinely used machining processes such as trimming and drilling for carbon fiber composites.

### 1.1 Composite Systems

Composites used in the aircraft industry could be organic, metal, and ceramic matrix composites (OMCs, MMCs, and CMCs). These are used in jet engine and air frame components. In jet engine for example, the engine cold section will incorporate OMCs, MMCs, and intermetallics. OMC components may include fan frames, fan blades, inlet and outlet guide vanes, stator vanes, cases, and control housings. Graphite-PMR-15 structural parts are used on such engines as GE F110 and F404, and PW-1120 and 1130. Hot sections, such as combustors and turbine exhaust, will require the high-temperature capabilities of some intermetallics, single-crystal superalloys, CMCs, or carbon/carbon composites.

The use of OMCs, especially carbon-fiber based composites for aerostructures, have been initially used on military airframes. Now carbon fiber composites are used extensively on commercial aircraft. Example parts are:

- Wing: Covers, Spars, Leading Edges, Flaps
- Fuselage: Panels, Stringers, Frames, Clips, Doors
- Tail: VTP & HTP Covers, Rudder, and Flaps
- Keel Beam, Centre Wing Box, Belly Fairing

The following are example aircraft and corresponding AWJ-machined components:

- Boeing 787 - center wing box, wing skins, spars, stringers, fixed leading edge, vertical stabilizer, 777 – horizontal stabilizer, 747 - titanium landing gear components - see Figure 1 below
- Airbus 350XWB – wing spars
- Bell Helicopter V-22 Osprey - wing skins, stiff rotors
- Raytheon Premier I – The fuselage.

The most common AWJ-cut carbon fiber composite parts in an air frame are found in:

Most revolutionary in the use of composites on commercial liners is the Boeing 787 which will contain 50% composite structure by weight and 90% by volume and the Airbus A350XWB with similar composite usage. In comparison, the 777, which

**(continued on page 12)**

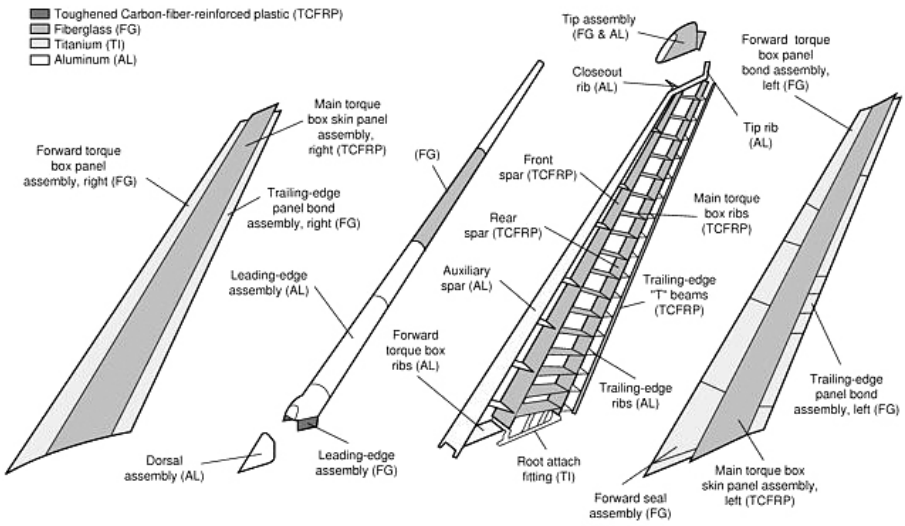



**Figure 1: 777 Tail Fin Composite Structures**

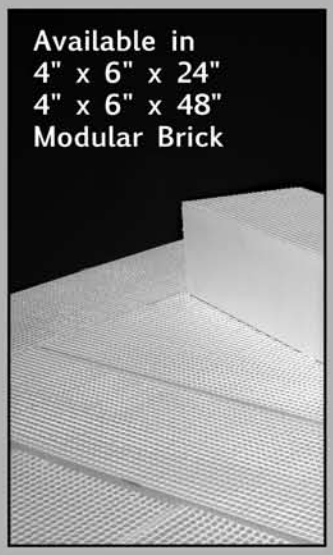
# Quality & Reliability
## *Now Availability*

# *DIRECT*

## GMA Garnet
## USA Corp.

*the most popular **Waterjet** cutting abrasive, worldwide — near you!*


**GMA Tuff Bricks**
*The Longest Lasting Waterjet Brick*




### U.S. Warehouses

*Garnet & Bricks Only Stored in Warehouses*

| | | |
|---|---|---|
| Atlanta, GA | Dallas, TX | St. Louis, MO |
| Baltimore, MD | Houston, TX | Tampa, FL |
| Chicago, IL | Kansas City, KS | Tulsa, OK |
| Cleveland, OH | Philadelphia, PA | Worcester, MA |

GMA Also offers a Full Line of Waterjet Replacement Parts Including:


*Dialine Cutting Head*


*Dialine Clamp-style Mounting*


*No "Minimum Order" Fees on Any Parts Purchased*

AUSTRALIAN GMA GARNET

## Hoppers

### Non-Pressurized Bulk Storage Hoppers

*Quick Fill, Easy Loading, Less Down Time*

*The non-pressurized bulk storage hopper holds 4400 lbs. of garnet and mounts above your existing pressurized hopper.*

### Pressurized Abrasive Hoppers

*Available in Five Sizes*

• 1.5 cu. ft. *holds 100 lbs* • 6.5 cu. ft. *holds 800 lbs.*
• 20 cu. ft. *holds 2400 lbs.* • 40 cu. ft. *holds 4500 lbs.*
• 50 cu. ft. *holds 6000 lbs.*
*Multiple discharge ports available*


GMA Garnet Corporate Office:
480 N. Sam Houston Pkwy. East, Suite # 130
Houston, Texas 77060

**Call: 832-243-9300**

gmausa@garnetsales.com

# Nominations Open For WJTA Board of Directors

Nominations for the WaterJet Technology Association (WJTA) Board of Directors are now open," says WJTA Secretary Hugh B. Miller, Ph.D. "The duties of the directors are truly challenging and rewarding."

The terms of office of Greg Galecki, Ph.D., Mohamed Hashish, Ph.D., Hugh B. Miller, Ph.D., Bill McClister, George A. Savanick, Ph.D., and B.T. Steadman will expire in August 2009. Therefore, nominations are sought for six (6) board members, each to serve a four-year term of office beginning August 17, 2009.

The WJTA bylaws provide that no more than one of the elected board members may be from the same company or organization. Therefore, board members may not be nominated from the same company or organization already represented on the board by individuals whose terms expire in 2011, including DeBusk Industrial Services Company (Pat DeBusk), High Pressure Equipment Company (Larry Loper), NLB Corporation (Forrest A. Shook), StoneAge, Inc. (John Wolgamott), Environmental Solutions Group/Federal Signal (Bill Gaff), and Polyflex Business Unit/Parker Hannifin Corporation (Paul Webster).

According to the WJTA bylaws, any WJTA member in good standing (2008 membership dues paid) may submit a nomination(s). A nominee who has not paid his/her dues by March 31, 2009, shall be declared ineligible to run for office in the 2009 election. The deadline for making nominations is **March 31, 2009.** Your nomination(s) should reach the WJTA office **no later than March 31, 2009.**

**To submit a nomination(s), complete the Nomination Form and return, along with biographical information and a brief statement of your nominee's mission and vision for WJTA, to:**

**WJTA Administrative Office**
**906 Olive Street, Suite 1200**
**Saint Louis, MO 63101-1448**
**Phone: (314) 241-1445**
**Fax: (314) 241-1449**

Remember, nominations must be received **no later than March 31, 2009.**

### Nominations/Elections Procedures

In accordance with the bylaws of the WaterJet Technology Association, nominations and elections to the Board of Directors include the following procedures:

- At least two calls for nominations to the board of directors will be published in the *Jet News*. The first call for nominations appears in this issue. **Nominations will be accepted through March 31, 2009.**
- An official ballot listing the eligible nominees and a brief biographical sketch for each individual will then be forwarded by mail to all eligible voting members of the Association on **May 28, 2009**. **Signed and executed ballots must be mailed to the Association's office for tallying by June 25, 2009.**
- The names of newly elected board members will be announced in the *Jet News* and on the WJTA web site.

Only WJTA members in good standing (2008 membership dues paid) may submit a nomination(s). A nominee who has not paid his/her dues by March 31, 2009, shall be declared ineligible to run for office in the 2009 election.

### Nomination Form

Name of Nominee_____

Title_____

Address_____

City_____ State_____

Country _____ Postal Code _____

Telephone_____ Fax_____

Email_____

_____ ***Attach biographical information with a brief statement of your nominee's mission and vision for WJTA.*** _____

Name of Nominator_____

Title_____

Address_____

City_____ State_____

Country _____ Postal Code _____

Telephone_____ Fax_____

Email_____

**Return completed Nomination Form and supporting information to:**
**WJTA Administrative Office, 906 Olive Street, Suite 1200, Saint Louis, MO 63101-1448**

Are you tired of slow production?
Looking to get more return on your equipment investment?

# PROBLEM SOLVED.

GATTI ORIFICES OUTLAST AND OUTPERFORM ANY OTHER ORIFICE ON THE MARKET.

Maximize your waterjet productivity. Choose to use GATTI sapphire orifice assemblies in your waterjet system.

- GATTI nozzle designs are recognized as the industry standard
- Our core business is manufacturing waterjet orifice assemblies and has been for over 30 years
- We are specialists in sapphire processing
- Same day shipping, excellent service, unmistakable quality

GATTI

524 Tindall Avenue • Trenton, NJ 08610
609-396-1577 • 877-AMGATTI • Fax : 609-695-4339
**www.gattiam.com**

**CALL TODAY**
**And We Will Ship You FREE Samples To Try In Your Own System!**

# Edmonton Waterjet Shop Experiences Nine Straight Years of Growth

When Garnett Gerke opened his Edmonton, Alberta, waterjet shop, G.O. H2O, more than ten years ago, he deliberately decided to target diverse markets rather than hinge his fate on a niche industry.

This approach has served G.O. H2O well. The company has grown every year for the past nine years, and even added a second waterjet table last year to keep up with demand.

"We attribute our growth to Alberta's strong oil and gas-based economy, but also to the fact that we market to other areas such as architectural, glass, flooring, metal fabricating and a small amount in plastics," Gerke noted.

Gerke credits his former business partner for coming up with the idea of opening a waterjet shop. His partner got the idea while working on a road construction crew in northern Alberta. The crew ran into challenges trying to drill through rock so he went online to research the idea of cutting material with something more innovative and efficient than coring methods. After some research, he determined that waterjet was the wave of the future in terms of cutting, and also found that Edmonton was considered the "machine shop capitol of the world," yet the city only had one waterjet shop at that time.

**Garnett Gerke of G.O. H2O, Edmonton, Alberta.**

**(continued on page 7)**

## Edmonton Waterjet Shop Experiences Nine Straight Years Of Growth, from page 6

Gerke's 12 years in the trades as a cabinetmaker coupled with four years of marketing experience came in handy as the men built their business. They decided to focus primarily on waterjet cutting rather than machining since the area was saturated with machine shops.

When they bought their first waterjet table, they chose a 4x12-foot High Rail Gantry manufactured by Jet Edge, Inc. of St. Michael, Minnesota. They equipped the table with two cutting heads and powered it with a 100hp, 55,000 psi (4,100 bar) Jet Edge 55-100 intensifier pump with dual intensifiers.

"We liked the idea that Jet Edge was a privately owned company versus a publicly traded company," Gerke said. "We also liked their reputation of quality."

G.O. H2O had racked up nearly 35,000 hours on its first system when Gerke and his new business partner, Don Torok, decided to buy a second system.

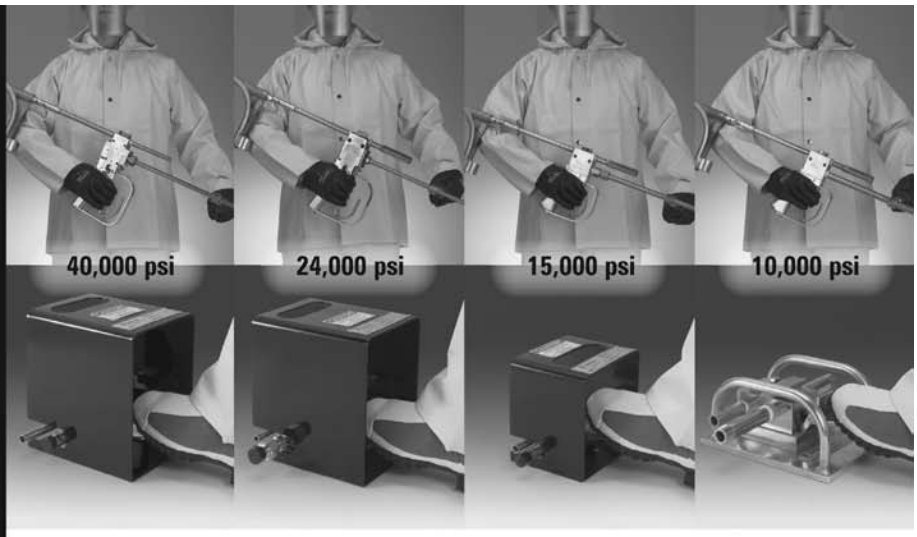
For the second system, the company went with a 6x12-foot Jet Edge High Rail Gantry so they could accommodate larger sheet sizes. They equipped this system with two cutting heads and a 55-100 Jet Edge intensifier pump. Both waterjet systems are equipped with overhead cranes, and Gerke noted that the tables are very easy to load by crane or forklift.

"When it was time to buy the second machine, it was very tempting to look at the other manufacturers, and we did, but how can you argue with 35,000 hours and very little downtime," Gerke said, noting that on his original ten-year-old pump, he has only had to replace one of the intensifiers. The electric motor and one intensifier are still original.

"When we did have downtime, Jet Edge's customer service was amazing, even on holidays," he added. "On one of the rare times our system went down, it went down over the U.S. Thanksgiving holiday, which is not a holiday for us. I called Jet Edge's emergency service contact, and they went in and shipped the part out. We were back up and running for the weekend."

After more than ten years of positive experiences, Gerke said he would

**(continued on page 20)**


**Get all your favorite features, at any pressure.**

**60-second cartridge change, instant pressure dump, and more**

When designing our latest lances and foot controls, we got advice from experts: operators who use water jets every day.

As a result, NLB's 60-second cartridge seal change and patented instant pressure dump are now standard on 10 lances and 4 foot controls. That's the most models in the industry — 10,000 to 40,000 psi — with no trade-off in performance or comfort.

We also offer these great features on some SPIN-NOZZLE® heads, multi-gun valves and Bi-Mode™ valves. So give your operators what they've asked for: call **1-877-NLB-7988** or visit **www.nlbcorp.com**.


*Bi-Mode™ Valve*


*MGV15-3000 Multi-Gun Valve*


*SRH40-77 Viper 40™*

**NLB. The Contractor's Choice.**

NLB Corp.

29830 Beck Road, Wixom, MI 48393
**MI:** (248) 624-5555, **TX:** (281) 471-7761
**NJ:** (856) 423-2211, **LA:** (225) 622-1666
**CA:** (562) 490-3277
**e-mail:** nlbmktg@nlbusa.com

# Flow Opens New Czech Republic Sales and Customer Service Center

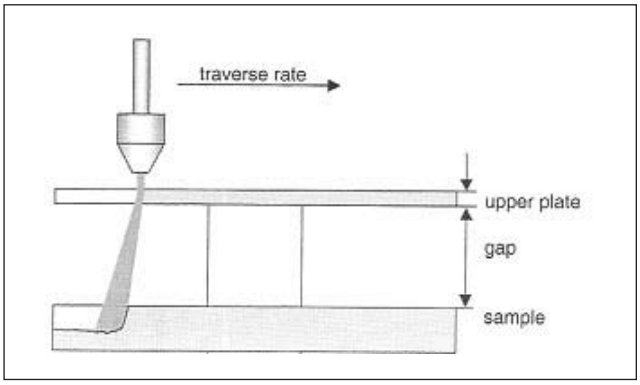
Flow International Corporation has announced the opening of a new sales and customer service center in the Czech Republic. The new center, located in Brno, Czech Republic, will serve customers in central and Eastern European markets, including Croatia, Slovenia, Hungary, Romania, Poland, Czech Republic, Slovakia, Russia, Belarus, and the Ukraine. The center was opened in response to the growth of Flow's European customer base in those countries and the future growth opportunities in these countries.

"As a result of the increased demand for waterjet cutting technology worldwide and Flow's growing European customer base, we seized the opportunity to open a sales and service center to best serve our Eastern European customers," said Charley Brown, CEO, Flow International. "The new center will complement our European headquarters in Bretten, Germany so Flow can continue to deliver the highest possible service to our growing European customer base."

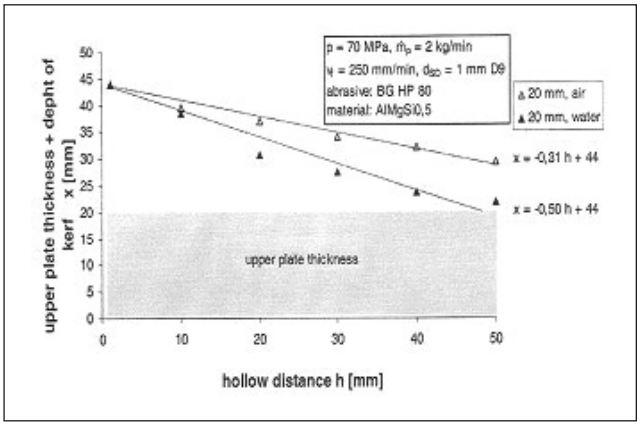
For more information, visit www.flowcorp.com.

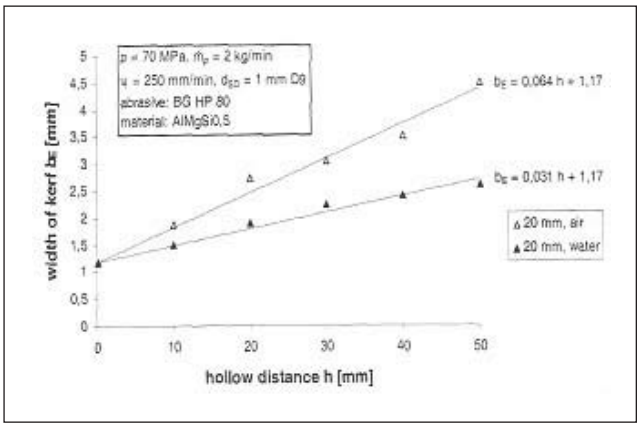

# Cutting Hollow Structures

Many applications in waterjet cutting are involved with hollow structures. The hollow space tends to disperse the jet and affects the cut below. Louis & Von Rad* did an experimental study on this phenomenon. Here is a review of their findings.




Their experimental setup to simulate a hollow structure is illustrated in the top figure. Cutting tests were done on aluminum with a 1-mm abrasive water suspension jet at 70 MPa of pressure and 2 kg/min of 80 mesh garnet. The parameters were chosen so that the sample below the gap was not cut through in order to preserve the evidences of remaining jet potential. The gap was filled with either air or water to study the impact of medium. The results were plotted in the other two figures.




The reduction of the kerf depth and the increase of the kerf width on the sample were proportional to the size of gap. Compared to air, water made the kerf shallower and narrower because the outer layer of the jet lost energy to the surrounding water. It was also found that the thickness of the upper plate had a small impact to the kerf-depth-vs- gap-size relation (i.e., a thicker upper plate resulted in a shallower kerf), but a relatively large impact to the kerf-width-vs-gap-size relation (i.e., a thicker upper plate resulted in a wider kerf). The explanation was that the upper plate acted as a "bad" nozzle.

*Louis, H. & Ch Von Rad (2000), "Cutting of hollow structures with abrasive water suspension jets," in Proceedings of the 15th International Conference on Jetting Technology, Ronneby, Sweden, September 6-8, pp59-67.

Reprinted by permission from *Quality Waterjet Newsletter*, October 7, 2008.

# Personnel Appointments

• **Jet Edge, Inc.,** has announced the appointment of **Eric Magnuson** as its new North Central regional sales manager. Magnuson is responsible for sales of Jet Edge waterjet systems in Minnesota, North and South Dakota, Wyoming, Nebraska, Western Iowa, Northern Wisconsin and Manitoba. He brings to Jet Edge more than 10 years of experience in capital equipment sales. Magnuson has a mechanical engineering degree from the University of Minnesota. He is based in St. Michael, Minnesota, and can be contacted at phone: (612)963-0933 or email: ericm@jetedge.com.

**Eric Magnuson**

• **Jet Edge, Inc.,** has also announced the appointment of **David J. Anderson** as its new international sales manager. Anderson is responsible for export sales of Jet Edge waterjet UHP pumps and systems. He brings to Jet Edge 15 years of experience in sales management, marketing, training and customer service in international and domestic business sales. Recently Anderson was an advisor to U.S. and foreign businesses regarding risk management, sales process, and marketing management. He has previous experience in sales and marketing management with specialized water pump capital equipment manufacturers. Anderson has traveled extensively throughout the world and has established OEMs, dealers, and distributors in approximately 35 countries on six continents. In 1997, the governor of Minnesota recognized Anderson's efforts and the company that he worked for at the time with the "Exporter of the Year Award." Anderson is based in St. Michael, Minnesota, and can be contacted at (763)497-8718 or sales@jetedge.com

**David J. Anderson**

• **SPIR STAR Ltd.** appointed a new sales representative, **Willie Whittington**, in September. Whittington has over five years of inside sales experience. His primary responsibilities will be to assist in the development of SPIR STAR's sales strategies and to help maximize customer satisfaction and performance. For more information, visit www.spirstar.com or call (281)664-7800.

**IMPORTANT NOTICE REGARDING SPAM**

Email addresses and other member contact information published in the WJTA Membership Directory is meant to encourage helpful, informative communication between members. The information is not provided to circulate spam or junk mail.

The WJTA leadership requests that members respect the contact information of fellow members and not use that information for the dissemination of spam or junk email. Membership information is not meant to be circulated beyond the WJTA membership.


# Select FS Solutions Centers Now Offer StoneAge Service And Repairs

To better serve industrial cleaning contractors, plant customers and other industry professionals, Federal Signal Environmental Solutions Group has announced that the FS Solutions centers in Toledo, Ohio and Long Beach, California, are authorized repair and service centers for StoneAge brand waterblasting and sewer cleaning tools, parts and accessories.

"At FS Solutions, we are proud to offer the kind of dependable products, parts and services – like the StoneAge line of waterblast tools – that our customers need to get the job done," said Bryce Mulligan, rental manager for FS Solutions. "We are also proud that the technicians at our Toledo and Long Beach centers have the training and expertise to repair and rebuild StoneAge products locally, rather than requiring customers to rely solely on the StoneAge service location in Durango, Colorado."

"There is physics behind how you make a water-spin tool and how you jet it," said Bill Shires, vice president of sales and marketing for StoneAge. "The technical sales specialists at FS Solutions have been fully trained by StoneAge engineers and are uniquely suited to answer customer questions about which StoneAge tools to use to remove specific materials in specific applications. FS Solutions also has the necessary machining expertise and tooling capabilities to repair our high tolerance tool components."

StoneAge products include the Hurricane® 3D vessel and tank cleaning tool, the Barracuda® 20,000 and 40,000 psi rotary nozzles and Warthog® sewer cleaning tools. "We are committed to building great tools," Shires said. "The location of the StoneAge factory is far from our customers' job sites. Having authorized repair locations minimizes shipping costs and time for everyone. We want our tools back in the operator's hands with the least amount of downtime as possible."

Since 1979, StoneAge, Inc., Durango, Colorado, has been a leading provider of high-pressure waterblast cleaning solutions. StoneAge products are used in a variety of industrial cleaning applications, including power plants, refineries, pharmaceutical companies and shipyards.

For more information about StoneAge products and services, call (866)795-1586, or visit www.stoneagetools.com.

For more information about products and services available from the FS Solutions centers or to find the nearest location, call (800)627-3171, ext. 298, or visit www.federalsignal.com.

WJTA
WaterJet Technology Association

# 2009 American WJTA Conference and Expo

Tuesday-Thursday, August 18-20, 2009
Marriott Houston Westchase, 2900 Briarpark Drive, Houston, Texas 77042

- **Live, Onsite Demonstrations** of a variety of waterjet applications (including cleaning, paint/coating removal, concrete preparation and testing of the effectiveness of safety equipment) and industrial vacuum/air moving operations.
- **Waterjet Expo** featuring displays of waterjetting equipment, systems and supplies and industrial vacuum/air moving vehicles.
- **Waterjet Boot Camp**—Industry experts offer information and suggestions on ways to help contractors buy smart, improve efficiency and generate profitable new business.
- **Pre-Conference Workshops**
  - **Waterjet Technology - Basics and Beyond**
  - **Vacuum Equipment Safety Seminar**
- **Emerging Technology, New Applications**—Hear some of the world's foremost engineers and researchers share new developments in applications, mechanics, equipment, and procedures.

The **WJTA Conference and Expo** is unique in that the program is dedicated to high pressure waterjet technology and related industries. If you are involved in high pressure waterjetting for cleaning, surface preparation, industrial vacuuming/air moving for industrial cleanup/recovery, waterblasting or cutting, or if you are interested in finding out more about the industry, the **WJTA Conference and Expo** is an ideal resource for information and an excellent meeting for networking with other professionals in the field.

**Hotel Reservations at the Marriott Houston Westchase.** The Marriott Houston Westchase, 2900 Briarpark Drive, Houston, Texas 77042, is the central location for the WJTA Conference and Expo activities. The Marriott is a **smoke-free** facility. For reservations, call toll-free **800-452-5110** or contact the Marriott directly at **713-978-7400.** Be sure to identify yourself as attending the WaterJet Technology Association Conference to receive the special group rates of **$149 single/double occupancy. August 2, 2009,** is the deadline for guaranteed room availability. Reservations received after **August 2, 2009,** will be confirmed on a space available basis. Rooms may still be available after August 2, but not necessarily at the rates listed above.

**Visit www.wjta.org for Conference information or contact:**
**WJTA, 906 Olive Street, Suite 1200, St. Louis, MO 63101-1448**
**Phone: 314-241-1445, Fax: 314-241-1449, Email: wja@wjta.org**

## Abrasive-Waterjet Machining Of Composites, from page 2

entered service just over ten years ago, contains only 10% composite structure by weight. The military's new F-35 Lightning II (JSF) expected to enter service in 2010 will have just below 40% composite structure by weight as Titanium Graphite (TiGr) laminates will be used. The F-22 Raptor, which entered service in 2003, has approximately 25% composite structures by weight. Figure 1 above shows the 777 tail fin with shaded areas being carbon fiber composite while Figure 2 shows the composite parts on the 787.

Typical problems that have been encountered when machining carbon fiber composites with conventional solid tools are matrix cracking, fiber pullout, inter-laminar voids, delamination, and resin melting. This leaves frayed or delaminated edges which require costly rework and slowdown of production cycles. Frequent tool change is required when using routers or drills due to the abrasive nature of the composite. Environmentally, solid tools generate dust and carbon powder which can wreak havoc on electrical systems and personnel.

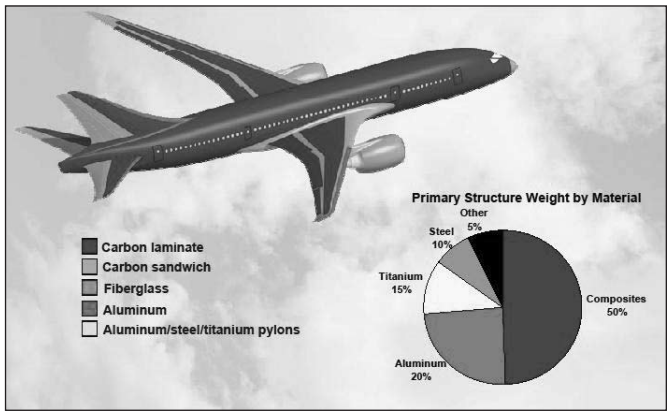



**Figure 2: Materials Used in the Boeing 787 Aircraft**

The above mentioned growing use of composite materials on primary aircraft structures requires technology offering lower manufacturing and tooling costs, and the reduced potential for product defects. For 2D and 3D cutting and machining of composite structures, AWJ technology offers several advantages over conventional machining methods. Among these advantages are:

- No distortion due to limited jet forces and its nature of micromachining action
- No heat affected zones
- Higher cutting speeds than routers

**(continued on page 13)**

- Reduced fixturing and tooling
- No delamination
- No subsequent processes are needed.
- No splintering or fraying edges
- Process automation and multi-operations are possible
- No dust

In the following sections we describe some advances in composite machining.

## 2. AWJ TECHNOLOGY ADVANCES FOR COMPOSITES MACHINING

There have been many advances in composites machining with AWJ for air frames that can be grouped into two basic categories. These are machinery (hardware) process, and software advances. The following are descriptions of some of these advances.

### 2.1 Hardware:

#### *2.1.1 Cutting Heads*

The use of vacuum assist in AWJ cutting heads, see Figure 3, has been critical for successful shapecutting of composites. An external vacuum source is used to draw abrasives into the cutting head before starting the waterjet. This insures an instantaneous action of the AWJ upon firing the waterjet and impacting the material. It has been shown that delimitation does not occur when piercing composites using this approach. The vacuum assist is particularly important when lower pressures are used as often is the case when piercing composites. In this case, the waterjet venturi effect is not sufficient to draw abrasives reliably into the cutting head and thus vacuum assist enhances the reliability of the AWJ process.

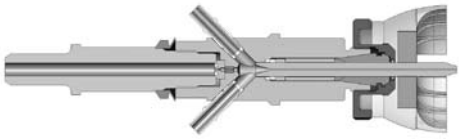


**Figure 3: AWJ Cutting Head with Vacuum Assist. One port is for abrasive feed and the other for attaching vacuum device.**

#### *2.1.2 Hybrid Waterjet System*

In order to trim and rout composites, both waterjets and solid tool routers have been incorporated on special hybrid systems as shown in Figure 4. In these systems, two 5-axis masts are used: one for the AWJ and another for the router. The AWJ is used to trim the part using an end effector

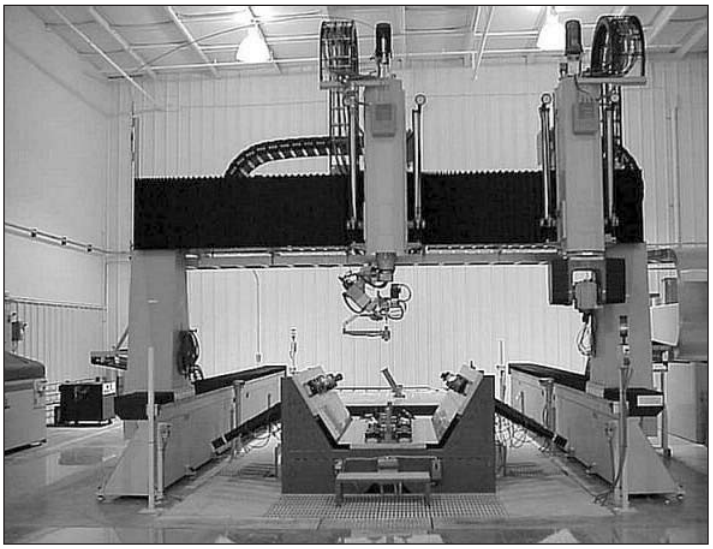
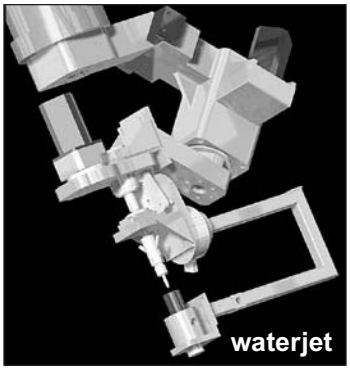
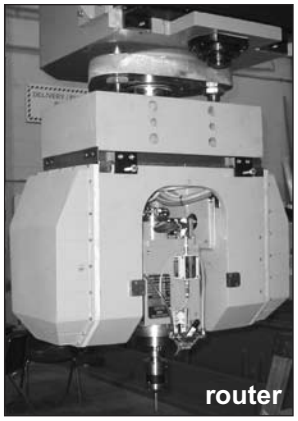


**Figure 4: Hybrid Waterjet System (Waterjet on the left, outer on the right)**




Wrist




Wrist

**Figure 5: AWJ and Mechanical End Effectors**

such as the one shown in Figure 5. Please note that a small catcher is provided on a 6th axis for catching the exit jet and directing the waste outside of the wrist area to the collection tank. The router, see Figure 5, is used to drill and counter sink the required holes or trim some critical areas not easy to address with the AWJ. This system provides significant advantage in minimizing set-up time. Machines range in size from 10 ft to 150 ft in length with width up to 50 ft. Probing and linear scales are used for obtaining the required accuracy.

#### *2.1.3 Flexible Fixturing*

Flexible fixturing is a key component in AWJ machining cells due to the wide variety of shapes and contours of airframe parts. FLOW has developed versatile fixtures consisting of a number of linear actuators with vacuum

**(continued on page 14)**

cups as well as hard location surfaces and points for accurately locating the part and rigidly holding it during cutting. The fixture must also accommodate the catcher and be specific to the waterjet nature as a long effective beam after penetrating the material. Figure 6 shows a fixture example for holding a wide range of curved parts as may be used in fuselage sections.

### 2.2 Software

Most airframe parts are designed using CATIA solid modeling software. In order to develop a CNC program to trim and drill parts, a post processor program is needed to translate the drawing such that the machine controller can execute it. This post processor also includes information about the process such as cutting speed, tool diameter, etc. This is a most critical element of the AWJ machining system as most parts are complex 3-D shaped. Flow International and CINET Systems developed FlowTrim: CAD (Data Import, Part Design, Fixtures, Run-off material), and CAM (Programming, simulation, tool path modification, …) as an integrated post processor using integrated cutting technology models and data tables. Figure 7 shows an example screen with the end effector and catcher displayed.

### 2.3 Waterjet Processes

The most common waterjet processes used for airframe are trimming, shapecutting, and drilling. Trimming is typically performed on the edges while shapecutting is performed on the interior surfaces to produce openings such as access holes or windows.

#### *2.3.1 Trimming and Shapecutting*

Significant work has been done on the use of waterjets and abrasive-waterjets for composite parts trimming. This trimming is required as parts are typically oversized due to the composite manufacturing process. A wide plateau of parameters has been found acceptable for cutting wide range of thicknesses - (0.1 inch to 3-inch) sections of graphite epoxy. The cut surfaces of better than 400 micro inches (as typically specified by Boeing) are achieved at relatively high productivity levels. For example, a

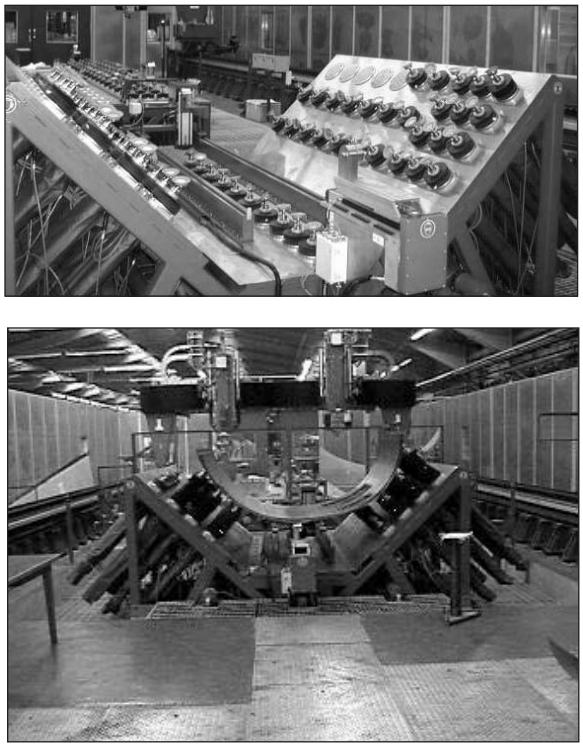


**Figure 6: Example Fixture for Holding Curved Parts**

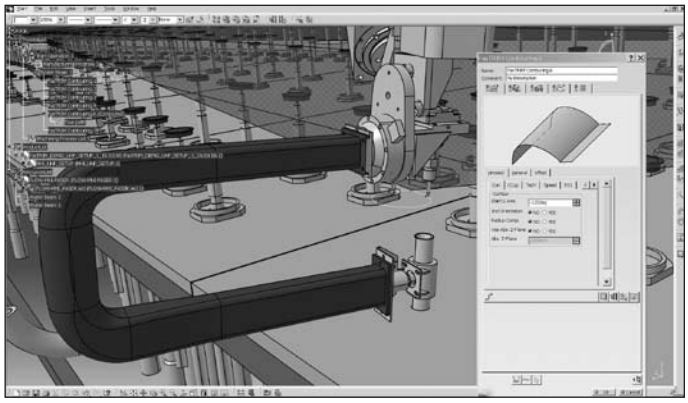


**Figure 7: FlowTRIM® Software Screen by CINET showing AWJ trimming end effector**

**(continued on page 15)**

## Safety Committee Solicits Comments On Improvements To Recommended Practices

The WJTA Safety Committee hereby solicits comments regarding improvements to the publication, Recommended Practices for the Use of Manually Operated High Pressure Waterjetting Equipment. While 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.

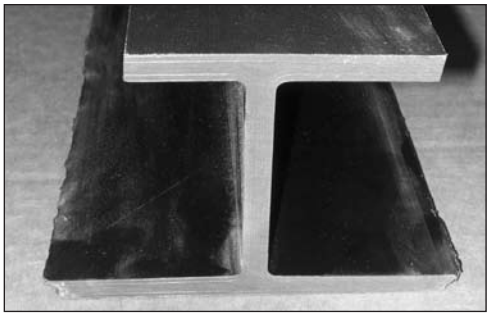
Please address your comments and suggestions to: Safety Committee, c/o WJTA, 906 Olive Street, Suite 1200, St. Louis, MO 63101-1448, phone: (314)241-1445, fax: (314)241-1449, email: wjta@wjta.org, web site: www.wjta.org.

## Abrasive-Waterjet Machining Of Composites, from page 14

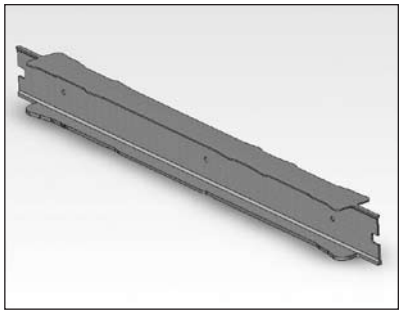
cutting speed of 20 inch/min can be used to trim a 0.35-inch thick carbon fiber using a 0.010 inch AWJ at 55 ksi.

Some edges may be trimmed at bevel angles, and when cutting around curves and complex contours, the effective depth of jet cutting varies and thus waterjet kinematics parameters such as speed and angles need to be carefully programmed to maintain uniform edge quality. Trimming I-Beam (stringer) composites requires special tooling such as catchers and cutting heads. Figure 8-a shows a cross section of a stringer with the top flange trimmed at 90 degrees with an AWJ. The bottom flanges show the condition of the edge before trimming. Figure 8-b shows a trimming overview example for the 787 aircraft stringers. The top and bottom flanges are shaped trimmed with the ends trimmed to the center rib or very close to it. Also, the bottom flange needs to be beveled at about 45 degrees. Some access holes are also drilled in the rib. These stringers, especially the ones used in the wings are relatively long, over 130-ft, and thus they require special machinery to handle them during cutting.

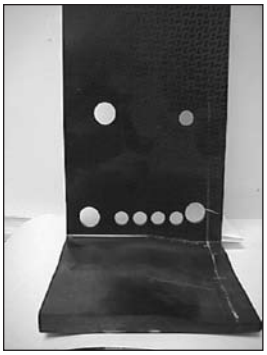
**Figure 8. Composite Trimming and Shapecutting Examples**



**a. Composite Stringer**



**b. Required Trimming of Stringer flanges and ends**



**c. Access Hole drilling at the root of a wing box stringer**

**d. AWJ trimming and cutting of complex 3-D composite wing part**

Shapecutting requires the piercing of a starting hole. Some systems use a mechanical drill to pre-drill the starting holes but most commonly now, AWJ is used to drill

**(continued on page 16)**

# Guzzler Reintroduces Predator™ Liquid Vacuum Tanker

Guzzler Manufacturing has announced the reintroduction of the Predator™ liquid vacuum tanker designed for handling bulk liquids, sludge and semi-solid waste in industrial applications.

"With the relaunch of the Predator, a full line of industrial vacuum trucks is now available from Guzzler Manufacturing, complete with the parts, service, training and industry expertise you expect from the Guzzler brand," said Tim Lee, product manager for Guzzler.

The liquid vacuum tanker combines high vacuum and pressure offloading designed to deliver reliable performance in the most demanding applications. The 3,000 gallon payload capacity tanker features a standard vacuum pump capable of suction pressures up to 27-29 inches Hg; maximum airflow of more than 400 CFM and more than 300 CFM at 18 inches Hg. Alternate pump sizes are also available.


The Predator's single compartment tank is constructed with carbon steel and is rated for continuous maximum vacuum operation and 15 psi working pressure. Built in accordance with Section VIII of

**(continued on page 23)**

these holes as part of the shapecutting sequence. In this case, vacuum assist nozzles are used to mitigate risks of delamination. Figure 8-c shows holes drilled at the root of a stringer rib. In order to cut near the bottom flange, a special minimal-size AWJ nozzle is used. The example trimming and shapecutting shown in Figure 8-d is quite complex due to the 3-D nature of the trimming in different planes. The design of a holding fixture in this example is of critical importance.

While the majority of trimming applications addresses relatively thin sections (less than 0.75 inch), there are several thick section (up to 3-inch) cutting applications near the wing-to-fuselage joining areas. Figure 9 shows example cuts in thick composite sections which were found to be faster than a mechanical tool by an order of magnitude using much less demanding fixtures and heavy equipment.

The end trimming of composite stringers (I-beams) is another application that requires careful 5-axis manipulation strategy as not to cause the exit jet damage the opposite sides of the stringer. Figure 10 shows a trimmed section from the end of a stringer. A rate of 1 inch/min can be used to cut through a 3-inch thick section producing an acceptable 400-micro-inch surface finish.

A most challenging cutting application is the cutting of composite honeycomb

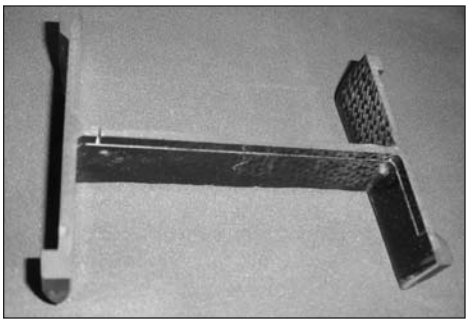
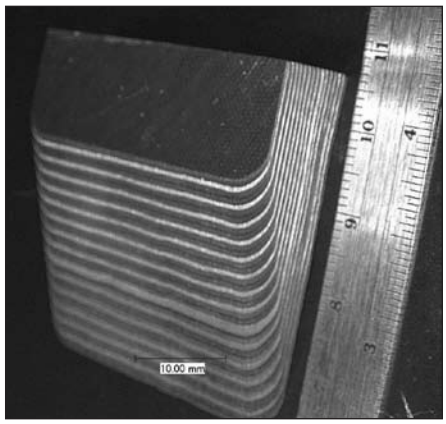


**Figure 10: Stringer end cut off**



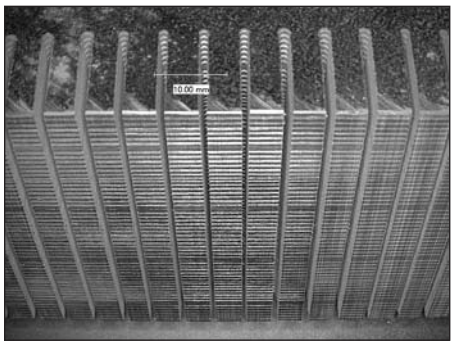


**Figure 9: AWJ-Cuts in Thick Composite Section**

structures as shown in Figure 11. Cutting this class of materials introduces additional challenge as the cutting path is not continuous. A cut at the bottom of a honeycomb structure appears as a series of punched holes. Cutting at a lead angle (a few degrees) has been found effective for minimizing this effect as shown in Figure 12.

### 2.3.2 Drilling (Piercing)

Delamination is the main mode of failure when drilling materials such

**(continued on page 17)**

# Federal Signal To Open Sixth FS Solutions Center In Gonzales, Louisiana

Federal Signal Environmental Solutions Group opened its sixth FS Solutions center in Gonzales, Louisiana on November 10, 2008. The new center, located at 3111 S. Darla Avenue, will stock high performance parts and accessories for Federal Signal's Jetstream brand of waterblasters, as well as other makes and models of waterblasters. The FS Solutions center will also offer customers the opportunity to rent or to own equipment and will sell used waterblasters.

"FS Solutions centers – like the new Gonzales location – provide the repairs, rentals, used equipment, parts and accessories and training our customers need to run their equipment more profitably," said Bryce Mulligan, rental manager for FS Solutions. "For customers interested in safety and improved productivity, the Gonzales FS Solutions center will offer waterblast safety training."

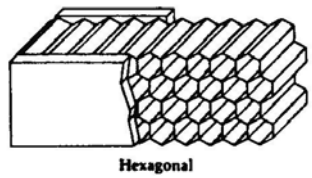
To help customers in Louisiana and the Gulf Coast area with their waterblast rental needs, the Gonzales center is staffed by knowledgeable employees with significant waterblasting experience. A customer looking for an extra waterblaster for a short-term or seasonal contract can choose from a full line of Jetstream units at the new Gonzales center – and FS Solutions will deliver the unit directly to the jobsite. Additional FS Solutions centers are located in Birmingham, Alabama; Long Beach, California; Houston, Texas; Toledo, Ohio; and Streator, Illinois.

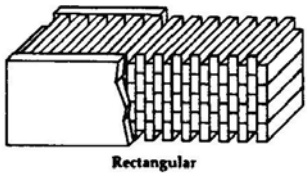
All FS Solutions locations provide access to factory-trained, certified technicians and genuine OEM parts. "FS Solutions customers look to our sales staff and service training technicians for recommendations and solutions to the unique challenges of their particular applications," Mulligan said. "Whether it's a contractor looking for faster, more cost-effective ways to perform cleaning operations or a business that can benefit from application expertise, equipment evaluations or training, we're providing solutions."

With nearly 100 years of collective experience in industrial vacuum loading, sewer and catch basin cleaning, vacuum excavation and industrial high-pressure waterblasting, FS Solutions offers unsurpassed expertise and a unique breadth of product lines and trusted brands to meet the needs of industrial cleaning contractors and other industry professionals.

For more information about products and services available from the FS Solutions centers or to find the nearest location, call (800)627-3171, ext. 298, or visit www.fssolutionsgroup.com.

## Abrasive-Waterjet Machining of Composites, from page 16



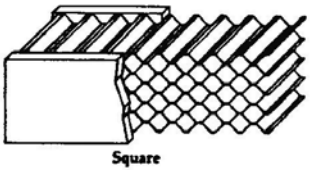




**Figure 11: Examples of Honeycomb Structures**

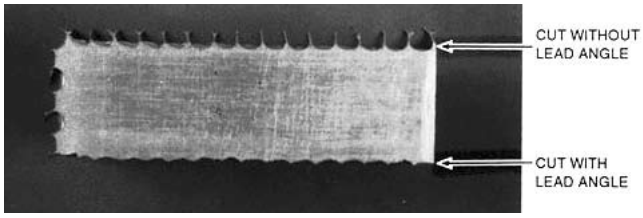



**Figure 12: Bottom Surface of 25-mm-thick Honeycomb Cut with an AWJ With and Without a Lead Angle (9°)**

**(continued on page 18)**

as graphite epoxy with waterjets. This problem is resolved when vacuum assist and proper parameters are used. Thousands of holes have been drilled in carbon fiber composites without any adverse effects. With proper process timing, holes can be drilled rapidly. While not as fast as laser, the holes are typically of high integrity and good surface finish. The AWJ process has been successfully investigated for rapid drilling (piercing) of holes in composites. For example, the picture shown in Figure 13 illustrated the drilling of 0.40 inch holes in a 0.040-inch thick composite material. The drilling time was about 0.9 seconds hole to hole.

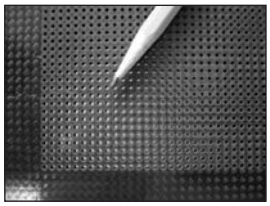


**Figure 13: AWJ-drilled holes in a carbon fiber composite panel (cover photo)**

The pierced hole size can be controlled by selecting the process parameters and the dwell time. The larger the dwell time, the larger the final hole size at the exit. Accurate control over the dwell time is needed to control the hole size within certain tolerance limits. Another interesting observation is that the drilling time is improved by reducing the water flow rate and increasing the abrasive flow rate into the hole.

### *2.3.3 Emerging Applications*

*2.3.3.1 Turning*

The turning of composite materials results in significant problems when using traditional turning and grinding techniques due to the multi-directionality of the composite lay-up and its abrasiveness. OMCs are typically not turned to produce parts, but with the ability of the AWJ to turn these materials, new designs may emerge using turned OMC parts. While many composite geometries have been turned, this application will not be discussed in this article.

*2.3.3.2 Milling*

The AWJ milling process is conducted by traversing the jets many passes close to each other across the workpiece surface. The multiple passes of overlapping kerfs are used to achieve controlled depth. The milling of isogrid shapes in graphite epoxy (Figure 14) was conducted to demonstrate the degree to which the depth of milling can be controlled. This approach involved the use of steel masks. It was found that depth control can be accomplished to 0.001 inch accuracy. The material can be milled ply by ply if needed suggesting its potential for repair applications

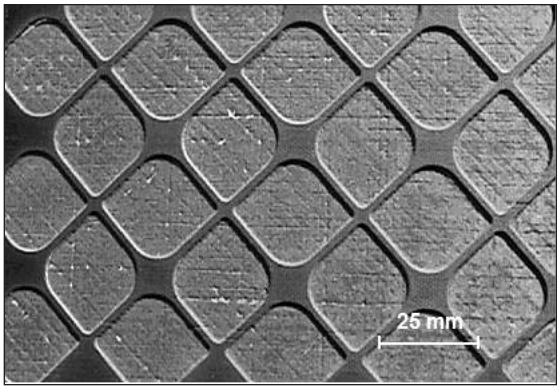



**Figure 14: AWJ-Milled Bosses (5 mm in diameter) in Gamma Titanium Aluminide**

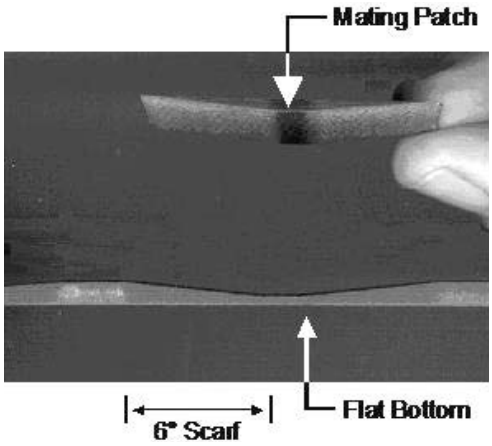



**Figure 15: AWJ-Milled Scarf Joint in Graphite Epoxy**

In the repair application, damaged material is first removed and then patched to the original geometry. The flexibility of AWJ cutting in a wide range of materials and shapes makes it suitable for the repair of composite structures. Alternatively, the AWJ could be used for milling off the damaged section or preparing the patch. For example, the AWJ can be robotically scanned over the surface producing a scarfed geometry suitable for repair as shown in Figure 15.

## 3. CONCLUSIONS

The AWJ process for composite trimming has now become a mainstream process since it was first introduced in the 1980s. Advances in the AWJ process combined with advances in machinery and software has made this technology acceptable for the aircraft industry. Today, all airframe manufacturers use AWJ for trimming composites. There are still needs for improved fixturing and AWJ tooling cutting heads and end effectors to address a wider ranger of parts geometries and sizes. New software and offline programming have been critical to the acceptance of the AWJ systems in the aircraft industry. ■

# Jet Edge's 90,000 psi X-Stream Waterjet Pump Increases Productivity Up To 50%

Capable of producing pressures in excess of 90,000psi, Jet Edge's new 100hp X-Stream xP90-100 waterjet intensifier pump achieves much faster cutting speeds and drastically lowers operating costs compared to traditional 60,000psi pumps, enabling users to increase productivity and reduce part costs.


The X-Stream produces 50% more pressure than a 60,000psi waterjet intensifier pump, resulting in a 40-50% increase in productivity for many materials. The X-Stream supports a 75,000psi continuous operating pressure. Compared to a 60,000psi pump, typical operating pressures of 75,000psi use 30% less water, 30% less power, and up to 50% less abrasive, resulting in a 40% reduction in operating costs. They typically reduce taper by up to 0.001 inch. The X-Stream is capable of producing flow rates of 1.45gpm and supports up to a .017 inch orifice. Its fittings and tubing are rated for 100KSI. The X-Stream is backed by nearly 10 years of extensive research and development in hyper-pressure technology.

For more information about the Jet Edge X-Stream xP90-100 intensifier pump or other Jet Edge waterjet equipment, visit www.jetedge.com, email: sales@jetedge.com or call 1-800-JET-EDGE (538-3343).

## Yellow Lube

A waterjet thread anti seize and thread lubricant that stays on the threads longer and will not stain your clothing or hands. Proven in some of the harshest Precision Cutting and Portable Waterjet environments. Available in the larger 6 oz. tubes.


Come see us at www.tsmoly.com under waterjet products.


Only One Of The Best

MEMBER WJTA WaterJet Technology Association

# SMT Diamond Orifices


800 hours* of usage is guaranteed, as long as it is properly used.

* We even have a customer that has used over 1,000 hours.

S M T

www.smttool.com
admin@smttool.com


### *Recommended Practices for Manually Operated High Pressure Waterjetting Equipment*

WJTA offers the *Recommended Practices for the Use of High Pressure Waterjetting Equipment* in English and Spanish. Topics include suggestions for personnel qualifications, operator training, and procedures for the proper operation of manually operated high pressure waterjet equipment used by the construction, maintenance, repair, cleaning and demolition industries.

The *Recommended Practices Safety Video*, available in CD-ROM or VHS, is the companion video to the *Recommended Practices for the Use of Manually Operated High Pressure Waterjetting Equipment*. The video is a visual depiction of the major topics in the *Recommended Practices*.

To place an order, see the WJTA order form for publications/products on page 31 or contact the WJTA office.

definitely recommend Jet Edge to other businesses. He said his systems have been very reliable, are easy to maintain and hold their tolerances very well. He has the machines recalibrated only once a year.

"We are so happy," Gerke said. "The ease of maintenance is excellent and the reliability of the machine is second to none."

With its Jet Edge systems, G.O. H2O is capable of cutting virtually any material. In fact, they have cut just about everything, from NHL logos on pumpkins to 12-inch thick steel. The company utilizes dual cutting heads on about 70 percent of its projects to double productivity.

G.O. H2O's most recognizable project can be seen at the Edmonton International Airport. Over the course of six months, the company cut 6,500 square feet of interlocking mosaic tiles for 27 large swirl patterns that were installed in the airport corridors.

"No matter who you talk to, if they ask you what you have cut, you can say, 'have you been to the airport?' and they all have seen the mosaics," Gerke said. "They do stand out."

Gerke noted that one of his most satisfying accomplishments was in successfully performing a test cut on .020-inch Pyrex® glass for a technology company. The company asked him to cut tiny rectangular openings out of the 2x3-inch Pyrex® pieces. They sent three sample pieces to 20 waterjet shops and G.O. H2O was the only shop that performed a successful sample cut. G.O. H2O got the project, and broke only three pieces out of 120.

In another notable project, G.O. H2O successfully separated a 30x48-inch, 12-inch-thick steel lifting lug by using a large nozzle and slowing the cut to 0.1-inch per minute.

**G.O. H2O's most recognizable project can be seen at the Edmonton International Airport. Over the course of six months, the company cut 6,500 square feet of interlocking mosaic tiles for 27 large swirl patterns that were installed in the airport corridors.**

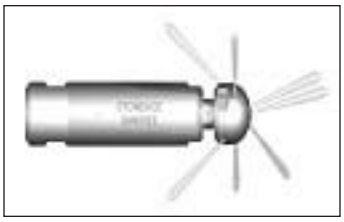
"The customer had done all the machining and they realized they needed to separate it," Gerke recalled. "People said we couldn't do it, but we did it. It was a feather in our cap."

G.O. H2O also has considerable experience cutting 1x3-inch test coupons of tough overlay materials for the oil recovery industry, Gerke noted. The coupons are typically steel

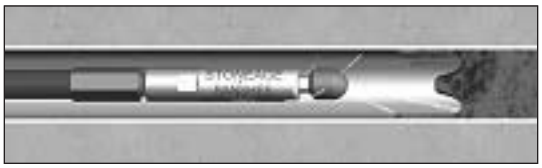
**(continued on page 22)**

# StoneAge Introduces the Banshee BN33: A New Tube Cleaning Nozzle

StoneAge has announced another addition to the Banshee family of tools – the Banshee BN33. The new Banshee is 33 mm in diameter and is capable of 20K psi and up to 50 gpm. The BN33 is suitable for tubes that are 1-1/2 inches to 2 inches in diameter.



The BN33 has a Universal style head designed for polishing and unplugging tubes at the same time. As with all Banshee tools the BN33 requires no maintenance and is available with a variety of inlet connections; ½-inch NPT, 9/16 MP, and BSPP. The Banshee BN33 is designed to replace the Marten (MT-P8) and Ferret (FT-P4) Tube Nozzles.



For more information, visit www.stoneagetools.com or contact StoneAge toll-free in the U.S. at (866)795-1586, phone: (970)259-2869, fax: (970)259-2868, or by email: sales@stoneagetools.com.

## *WJTAListServ* - A Free Service To WJTA Members

The ***WJTA****ListServ* enables you to take advantage of prompt email interaction with your colleagues. ***WJTA****ListServ* is a **FREE** email broadcast system developed by WJTA to help you communicate and network with other waterjet professionals.

Participation is limited to WJTA members in good standing. You must sign up in order to participate. To sign up for the ***WJTA****ListServ*, contact Beth at the WJTA office by email: wjta@wjta.org, phone: 314-241-1445, or fax: 314-241-1449.

## WJTA Administration

**Chairman of the Board**
John Wolgamott
(970)259-2869

**President/Jet News Editor**
George A. Savanick, Ph.D.
(952)432-7594

**Vice-President**
Pat DeBusk
(281)842-8000

**Treasurer**
Larry Loper
(800)289-7447

**Secretary**
Hugh B. Miller, Ph.D.
(303)273-3558

**2007-2009 Directors**

Bill Gaff
(815)673-3835

Bill McClister
(713)307-2142

Greg Galecki, Ph.D.
(573)341-4938

Forrest Shook
(248)624-5555

Mohamed Hashish, Ph.D.
(253)850-3500

B.T. Steadman
(601)933-4650

Paul Webster
(281)925-4509

**Emeritus Members**

Andrew F. Conn, Ph.D.
(410)532-3452

Thomas J. Labus
(262)245-9702

Thomas J. Kim, Ph.D.
(401)874-5991

Fun-Den Wang, Ph.D.
(303)279-9415

**Association Managers**

Mark S. Birenbaum, Ph.D. • Kenneth C. Carroll
(314)241-1445


## Edmonton Waterjet Shop Experiences Nine Straight Years Of Growth, from page 20

that has been overlaid with a very hard material such as tungsten carbide or ceramic.

"The tar sands are full of sand and abrasive and they are very hard on equipment so everyone and his dog is trying to come up with a wear product to overlay on steel," he said. "We do a lot of overlay samples. We have to slow them down to 0.1-inch per minute and they are still difficult to cut."

One of Gerke's proudest accomplishments has been figuring out a way to efficiently recycle the abrasive material he uses in the majority of his jobs. Leave it to a guy name Garnett to come up with an effective method for reusing garnet.

"In our first two years [cutting 24/7], we had to shut down every seven to ten days to clean out the tank," Gerke recalled. "We would be down 8 to12 hours. We had a sump truck come in and pump out the tank and haul the garnet off to the landfill. The first year, he charged $400 per visit. Two years later, it was three times the cost."

After his second year in business, Gerke installed a WARDJet abrasive recycling system to reduce his downtime and counter rising landfill costs. He reclaims 50-70 percent of his garnet, and said the system paid for itself within nine months. After he installed his second waterjet system, Gerke came up with an ingenious way to recycle garnet from both systems without having to buy a second recycler. He equipped the second table with a Jet Edge abrasive removal system with two side-loading dumpsters. After he fills one dumpster, it is replaced with an empty dumpster. The full dumpster is then dumped into the recycler. This allows him to keep his new table up and running with no downtime. Once a year, he cleans out the drops from both tanks.

To keep a good cutting edge, Gerke mixes his used abrasive with new abrasive. He said has not noticed any slowdown in cutting speeds since he started recycling.

For more information about G.O. H2O, visit www.goh2o.com, email goh2o@telusplanet.com or call 1-877-43-GOH2O (434-6426). For more information about Jet Edge, visit www.jetedge.com, email sales@jetedge.com or call 1-800-JET-EDGE (538-3343). ■

## Jet Edge Selected To Participate In Minnesota's Business Development Mission To Israel

Jet Edge International Sales Manager **David J. Anderson** joined the Minnesota Trade Office's Business Development Mission to Israel, Dec.11-18, 2008. Anderson is one of 30 business delegates who participated in the mission led by Minnesota Gov. Tim Pawlenty. The delegation's objectives are to acquire market information and business contacts, increase Minnesota exports to Israel, facilitate high-tech exchanges and collaboration, and develop strategic relationships with key organizations that support U.S.-Israeli trade and investment.

As one of the world's most prominent centers of innovation and technology, Israel offers a wealth of opportunities for high-tech exchanges and collaboration. Additionally, with one of the best economic growth rates in the Middle East and an affinity for American products, Israel presents significant market opportunities for Minnesota exporters.


Jet-BRICK™

*by PR Specialty Products, Inc.*


- Provides smooth level cutting surfaces
- Ideal for cutting small parts that would otherwise need to be tabbed
- Ideal for cutting flexible materials
- Laminated design significantly reduces noise level
- Excessively worn brick can be easily replaced simply by inserting a new ***Jet-Brick*** section
- Reduces splash back that can damage the surface or lift matreials

**Material:** 300# HDPE extruded, laminated plastic

**Colors:** White or Black

**Sizes:** Standard size in 4C"* x 6"x 48",
**direction of corrugated flute*

Custom sizes up to 96" are available

*Call or email us for a quote!*

414-489-0450 • www.waterjetbricks.com • info@pak-rite.com

# Barton Mines Announces Expanded Capacity At HPX™ Processing Plant

Barton Mines Company has announced the expanded capacity of their HPX™ waterjet abrasive processing facility in North Creek, New York.

The increased production is a direct result of a comprehensive plant re-engineering and expansion that commenced in September 2007. "The additional volume comes at a time when demand for HPX has grown exponentially," says R. Randolph Rapple, President.

Barton HPX™ high performance abrasives have a unique structure that produces sharp angular crystals. This unusual trait enables Barton HPX™ to outperform all other waterjet abrasives. The sharper, more angular edges make HPX™ the fastest cutting waterjet abrasive. Barton HPX™ produces a better edge quality and can be used in demanding applications where other waterjet abrasives fall short. In addition, Barton HPX™ waterjet abrasives are the cleanest cutting media available. This translates to less downtime due to clogged jets or erratic abrasive feed and a more cost-efficient operation.

Barton offers eight grades of HPX™ waterjet abrasives. To learn which HPX™ grade is best suited for a particular application or to order product samples, visit www.barton.com, or contact Barton Mines Company by email: info@barton.com or call toll free: (800)741-7756.


## Guzzler Reintroduces Predator™ Liquid Vacuum Tanker, from page 15

the American Society of Mechanical Engineers boiler code, the tank also complies with the U.S. Department of Transportation specification DOT412 for hauling hazardous materials on the highway.

"Industrial cleaning professionals look to Guzzler for unique solutions to their particular applications," Lee said. "We are proud to reintroduce the Predator liquid vacuum tanker and are confident that our customers will appreciate our one-stop shop solution to address their industrial cleaning needs."

For more information on the Predator liquid vacuum tanker from Guzzler Manufacturing, visit www.guzzler.com or call (800)627-3171.

# Maxpro Technologies Expands Houston, Texas, Operation

Maxpro Technologies has announced the expansion of Maxpro South, their Houston, Texas operation, into the states of Louisiana, Alabama and Mississippi.

This move will provide more direct support to the water blast industry in the region. Water blasting, oil and gas and other industries that use the Maximator line of high pressure valves, fittings and tubing will benefit from this increased technical support, sales and service.

**Kim Guidry**, located in Lafayette, Louisiana, has been appointed technical sales representative to head up this expansion. Guidry earned a B.S. degree in Industrial Technologies from the University of Southern Louisiana and brings over 20 years of experience in the high pressure industry. He can be contacted at (337)280-4223 or via email at kim@maxprosouth.com.

Maxpro Technologies is the North American distributor of Maximator high pressure valves, fittings and tubing as well as air powered products including liquid pumps, gas boosters and air amplifiers. Maxpro also designs and manufactures various standard and custom pressure systems utilizing these Maximator products.

For more information visit us online at www.maxprotech.com, or call (814)474-9191.

The *Jet News* is published by the WaterJet Technology Association (WJTA) and is a benefit of membership in the Association.

©2008 *Jet News*. All rights reserved. Reproduction in any form forbidden without express permission.

## *Notes From Another SUPER-WATER® User:*

Special thanks to Renato Lombari for the following notes:

I have worked with ultra-high pressure waterjets, operating up to 55,000 psi, for 19 years and SUPER-WATER® for 12 years. This includes:

- plain water
- plain water + SUPER-WATER®
- plain water + abrasive
- plain water + SUPER-WATER® + abrasive

My work, during this time, gives an unambiguous demonstration of the economic advantages of using SUPER-WATER® (1,2,3). Relative to plain water, the addition of SUPER-WATER® to an ultra-high pressure waterjet cutting system:

- improves the quality of cut (6) (An excellent example of this enhanced quality was published by Weber [1997].)
- increases cutting speeds by 30% to 200% (non-abrasive cutting system)
- reduces intensifier operating and maintenance costs by 38% (non-abrasive cutting system)
  [from $11.12/hr (1993) to $6.86/hr (1996) = $4.26/hr reduction]

These results were for cutting fiberglass acoustical panels using an intensifier. My results also parallel those previously published for precision cutting of natural-, synthetic-, silicone-, and foam-rubber (4) as well as synthetic materials such as Vistanex (5) and shoe soles (4).

I have used SUPER-WATER® 100% of the time. Waste water and abrasive was disposed of without any problems. I have typically cut the following materials:

- 304, 316 stainless steel
- duplex stainless steel
- aluminum (various alloys)
- titanium
- brass (various alloys)
- clear float glass
- laminated glass
- slate
- blue tempered steel
- hot and cold rolled steel
- marble and granite
- acrylic
- ultra-high molecular weight polyethylene
- plywood, MDF and particle board

For a detailed analysis of abrasive cutting speeds and cut surface quality, please see the SUPER-WATER® groups file named "Reduction in Abrasive Consumption.doc" posted 04/21/2002.

I have found that an approximate 0.1% to 0.2% SUPER-WATER® solution produces the following three-fold effects:

- Reduces flow resistance due to substantial drag reduction.
  Hoyt (1986) produced laboratory turbulent rheometer findings showing that even 9 ppm resulted in a 20% drag reduction and Cobb and Zublin (1985) obtained a drag reduction of 54% in 2187 meters of 2.16 cm (0.85 inch) id coiled tubing.
- Collimates the jet leaving the nozzle
- Introduces macromolecular bombardment (Kudin et al., 1973) of polymer molecules dissolved in the water

**REFERENCES**


1. R. Lombari, "Ultra-High Pressure Non-Abrasive Polymer Jetting: A Production Environment Implementation," Proceedings of the 9th American Waterjet Conference (Dearborn, Michigan: August 23-26, 1997), Paper 17, pp. 251-266.
2. R. Lombari, "Cutting Fiberglass Acoustical Panels," Jet News, December 1995, p. 7.
3. R. Lombari, Letter to the Editor, ... "the longevity of our consumable jet components due to the lubricity of SUPER-WATER®," Jet News, November 1996, pp. 2 and 11.
4. W.G. Howells, "Polymerblasting with SUPER-WATER® from 1974-1989: a Review," International Journal of Water Jet Technology, Volume 1, Number 1, (March 1990), pp. 1-16.
5. W.G. Howells, "Additive Improves Abrasive Jet Cutting," Jet News, December 1995, pp. 5 and 10.
6. D. Weber, Letter to the Editor, Jet News, February 1997, p. 12.



For more information and references, visit **www.berkeleychemical.com**, email: **wglennhowells@webtv.net**, or contact W. Glenn Howells, Ph.D., President, Berkeley Chemical Research, Inc., Tel: 510-526-6272, Fax: 510-525-2375, Mail: PO Box 9264, Berkeley, CA 94709-0264.



**-ADVERTISEMENT-**

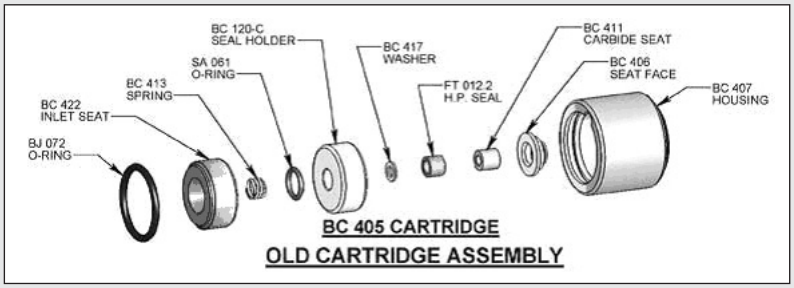
# StoneAge Upgrades the 40K psi Barracuda Cartridge

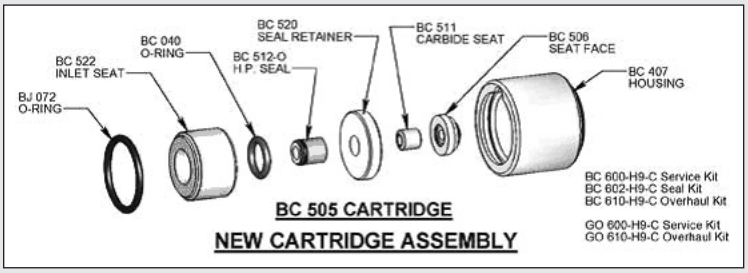
StoneAge is offering an upgraded cartridge assembly that will retrofit into existing 40K psi Barracuda, Gopher, and SL tools and is being supplied with all new tools as of November 20, 2008. This upgrade is designed to increase the operational life of the high pressure seals.

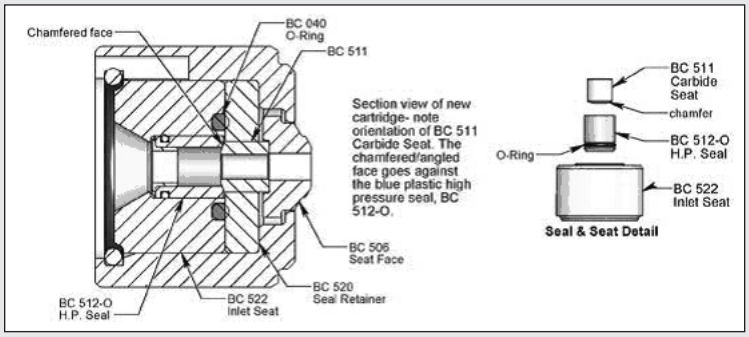
The following diagrams illustrate how StoneAge is replacing the BC 405 Cartridge Assembly with the new BC 505 Cartridge Assembly. Several of the items have changed.

These BC 505 Cartridge Assemblies became available on November 20, 2008. If you have existing stock of the old cartridge assemblies or the individual parts, StoneAge will accept those unused items for credit return. Visit www.stoneagetools.com to download or print these drawings.

StoneAge is continually working to create new products and improve existing products, and welcomes your feedback about this upgrade and your success with this product improvement. Contact StoneAge toll-free in the U.S. at (866)795-1586, phone: (970)259-2869, fax: (970)259-2868, or by email: sales@stoneagetools.com.




# WJTA Welcomes New Members

## Corporate

**Stewart R. Browne Manufacturing Co. Inc.**
*Alan R. Browne*
*James Browne*
1165 Hightower Trail
Atlanta, GA 30350
Phone: (770)993-9600
Fax: (770)594-7758

**IMS Maintenance Services**
*Maurice Duguay, Jr.*
P.O. Box 6
Timmins, ON P4N 7C5
Canada
Phone: (705)235-9274
Fax: (705)235-8989

*Moe Duguay, Sr.*
979 Goldmine Road
Timmins, ON P4N 7C5
Canada
Phone: (705)264-1642
Fax: (705)235-8989

*Trevor Niemi*
Timmins Jacobile Wash
24 Hollnor Road
Porcupine, ON P0N 1C0
Canada

**Keith Huber, Inc.**
*Alan Klaser*
14220 Highway 49 North
Gulfport, MS 39503
Phone: (228)832-0992
Fax: (228)832-2068

**Kroy Industries, Inc.**
*David D. Le Duc*
*Phillip Seever*
522 W. 26th Street
P.O. Box 309
York, NE 68467
Phone: (402)362-6651
Fax: (402)366-6566

*Albert Reyna*
5223 89th Street
Lubbock, TX 79424
Phone: (806)798-2015
Fax: (806)798-2018

## Corporate Alternates

**Stephen Davis**
KMT Aqua-Dyne, L.P.
3620 West 11th Street
Houston, TX 77008-6004
Phone: (713)864-6929
Fax: (713)864-0313

**Pedro Hans Dominguez**
TNT High Pressure Waterworks, Ltd.
9451 49th Street
Edmonton, AB T6B 2L8
Canada
Phone: (780)469-4073
Fax: (780)463-2077

**Rex Foster**
Prepcon, Inc.
6737 Dogwood Road
Baltimore, MD 21207-4121
Phone: (410)265-6722
Fax: (443)200-1010

**Chris Kay**
Super Products LLC
17000 W. Cleveland Avenue
New Berlin, WI 53151-3593
Phone: (262)784-7100
Fax: (262)784-9561

**Greg Loraine**
DYNAFLOW, Inc.
10621-J Iron Bridge Road
Jessup, MD 20794-9381
Phone: (301)604-3688
Fax: (301)604-3689

**Jonathan Lukas**
HydroChem Industrial Services, Inc.
900 Georgia Avenue
Deer Park, TX 77636-2518
Phone: (713)393-5624
Fax: (713)393-5959

**Iris Montemayor**
Nuova Fima, USA
15255 Gulf Freeway
Suite 148D
Houston, TX 77034-5351
Phone: (281)464-0500
Fax: (281)464-0506

**Alfredo Sanchez Oviedo**
Representaciones Industriales JBL S.A. de C.V.
Gomez Farias #1957
Col: Flores Magon
Veracruz, Ver. 91900
Mexico
Phone: [52](229)932-5672
Fax: [52](229)932-6278

**Brian Ritchie**
Denholm Oilfield Services UK, Ltd.
Greenbank Place
East Tullos Industrial Est.
Abedeen, Scotland AB12 3BT
United Kingdom
Phone: [44](1224)248600
Fax: [44](1224)248032

**Stefano Roti**
Pratissoli Pompe
Via Enrico Fermi 25
S. Ilario d' Enza
Reggio Emilia 42049
Italy
Phone: [39](522)904311
Fax: [39](522)904444

**Arnie Salinas**
GMA Garnet (USA) Corporation
480 N. Sam Houston Pkwy E
Suite 130
Houston, TX 77060-4108
Phone: (832)243-9300
Fax: (832)243-9301

**Tom Sanders**
KMT Aqua-Dyne, L.P.
3620 West 11th Street
Houston, TX 77008-6004
Phone: (713)864-6929
Fax: (713)864-0313

**Rene Stuehlinger**
BHDT GmbH
Werk-VI-Strasse 52
Kapfenberg A-8605
Austria
Phone: [43](3862)303-315
Fax: [43](3862)303-304

**Ulrich Thomas, Ph.D.**
Aqua Drill International
1300 FM 646 East
Dickinson, TX 77539-3022
Phone: (281)337-0900
Fax: (281)337-7270

**Matthew Verghese**
Hydrolink FZE
Jebel Ali- Headquarters
PO Box 18502
Dubai
United Arab Emirates
Phone: [971](4)8861414
Fax: [971](4)8861413

## Individuals

**Marcos Requena Arcajo**
Ingenieria Y Plantas De Proceso S.L.
Parque Empresarial Principado
De Asturias Avda. del Zinc s/n
Primero - Oficina nº2
Avilés, Asturias 33400
Spain
Phone: [34](98)5514476
Fax: [34](98)5514477

**Eric Bieberich**
Fort Wayne Wire Die, Inc.
2424 American Way
Fort Wayne, IN 46809-3005
Phone: (260)747-1681
Fax: (260)747-4269

**Frank Blaine**
Kitchell Environmental Services
1707 E Highland Avenue
Phoenix, AZ 85016-4640
Phone: (602)222-5300
Fax: (602)264-9296

**Allan Cox**
Atlantic Industrial Cleaners
11 Brown Avenue
Dartmouth, NS B3B1Z7
Canada
Phone: (902)468-9011
Fax: (902)468-5977

**Rob Haviland**
Crowe Manufacturing
216 S. Torrence Street
Dayton, OH 45403-2625
Phone: (937)254-4441
Fax: (937)254-4475

**Ignacio Lastiri**
Vialven SA
Mirave 2742
Buenos Aires C1281ABB
Argentina
Phone: [54](11)4303-3415
Fax: [54](11)4303-3417

**Henry Yang**
Semlima Industrial Company, Ltd.
19, 36th Road
Taichung Industrial Park
Taichung 40700
Taiwan, Republic of China
Phone: [886](4)23550190
Fax: [886](4)23550196

*Best wishes for a Happy, Healthy and Safe New Year from the WJTA Officers, Board of Directors & Staff*

# Jet Edge Introduces Easy-to-Use CAD/CAM Nesting Software For Waterjet Cutting

Jet Edge is now offering the easy-to-learn and use SigmaNEST Companion™ CAD/CAM nesting software on its precision waterjet cutting systems.

Developed by SigmaTEK Systems, LLC, of Cincinnati, SigmaNEST Companion uses a wizard-based approach to allow waterjet operators with little or no CAD/CAM experience to design, edit and nest parts quickly with little training. Available at a fraction of the cost of the full SigmaNEST program, Companion features numerous SigmaNEST functions such as DXF import, TrueShape nesting, automatic path generation, and NC code generation. With it, waterjet operators can load DXF files to automatically or manually nest parts. They also can create new tasks using standard shapes available in the program's library. Companion also allows operators to edit part parameters and generate a variety of custom reports, including cost, layout and summary reports.

Jet Edge manufactures a full line of precision waterjet cutting machines, intensifier pumps and waterjet parts. Jet Edge waterjet tables are available in a wide range of sizes, from 30 inchesx30 inches to 30 feetx100 feet. Jet Edge waterjet intensifier pumps are capable of producing pressures from 30,000psi to 90,000psi. They are available in electric and diesel models ranging from 30hp to 280hp. Jet Edge's open-architecture motion controllers are compatible with most CAD/CAM software, including SigmaNEST and SigmaNEST Companion.

For more information, visit www.jetedge.com, call (800)JET-EDGE (538-3343) or email sales@jetedge.com. For more information about SigmaNEST, visit www.sigmanest.com, call (513)674-0005 or email sales@sigmanest.com.



International Waterjet Parts
A DIVISION OF WGI

VISIT OUR WEB SITE WITH OVER 400 PRODUCTS, INSTALLATION PROCEDURES, EXPLODED VIEWS AND SERVICES

- PARTS FOR ALL MAKES OF MACHINES
- SAME DAY SERVICE
- UNSURPASSED QUALITY
- VALUE PRICING
- SATISFACTION GUARANTEE

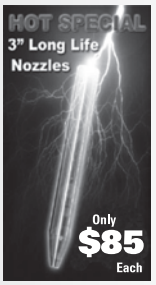
ADDITIONAL 5% DISCOUNT ON PARTS ORDERS FROM OUR WEB SITE

Additional 5% discount on parts orders from our web site.

We offer Ceratizit brand nozzles to fit most cutting heads.

**Don't settle for less when you can have the best!!!!**

CERATIZIT




INTERNATIONAL WATERJET PARTS INC.
A Division of WGI
1299 A STREET SE
EPHRATA WASHINGTON 98823

Phone: 509-754-3284
Toll Free: 866-302-3284
Fax: 509-754-3292
Toll Free: 866-883-3292
Email: iwp@iwpwaterjet.com

**WANT TO CUT YOUR GARNET USAGE UP TO 30%? CALL US TO ASK US HOW.**

# 2009 American WJTA Conference And Expo

August 18-20, 2009

Marriott Houston Westchase Hotel ● Houston, Texas, USA

## 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, oil and gas, power plants, process, and medical industries — continues to expand at a rapid pace.

The **2009 American WJTA Conference And Expo** will focus, from a practical and scientific viewpoint, on the most up-to-date 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 and Equipment**
- **Automotive and Aerospace 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**
- **Hydrodemolition**
- **Hydroexcavation**
- **Jet Mechanics and Visualization**
- **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**
- **Vacuum Equipment**

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 the back of this sheet, attach a copy of your abstract(s), and forward to the attention of the Conference Coordinator at the WaterJet Technology Association. An electronic submission form can be found on the WJTA web site at www.wjta.org. **The deadline date for submission of abstracts is January 15, 2009.**

An Abstract Review Committee consisting of five referees will review the abstracts. Authors will be advised by **February 27, 2009**, regarding the decision of the Abstract Review Committee.

The 2009 American WJTA Conference And Expo is organized by the **WaterJet Technology Association**. The WaterJet Technology Association looks forward to providing this forum and to your involvement and participation.

## Authors - Please Note

- Papers must be original. Papers must not have been published elsewhere or be pending publication.
- **Publication Fee.** A nonrefundable publication fee (equal to the price of a member Full Conference registration) is required. **This publication fee will be waived if at least one author registers (Full or Combo) for the WJTA Conference.** (Authors must pay the applicable member or nonmember price.) Also, one registration is good for multiple papers. The deadline date for receipt of your final paper will be **May 4, 2009**. The publication fee or payment for a Full or Combo registration is due no later than **June 15, 2009**. Your paper will **NOT** be included in the *Proceedings* if the publication fee or registration fee is not paid by this date.
- Papers and presentations must be in English. Papers should be no longer than 15 printed pages. A "Paper Guide" containing directions for submitting papers will be forwarded to you after your abstract is accepted. Papers that do not follow the "Guide" will be returned to the author(s) for correction(s) or charged a fee for revisions made by the WaterJet Technology Association office.
- Papers should be free of commercialism.
- Papers should be submitted as a Word file and a PDF file.

### 2009 WJTA Conference Committee

**Pat DeBusk**
Co-Chairman
DeBusk Industrial Services Company

**Bill McClister**
Co-Chairman
Veolia Environmental Services

**Mohamed Hashish, Ph.D.**
Editor
Flow International Corporation

**Bill Gaff**
Jetstream of Houston, LLP

**Hugh B. Miller, Ph.D.**
Colorado School of Mines

**Gary Noto**
Veolia Environmental Services

**B.T. Steadman**
Vacuum Truck Rentals, LLC

WJTA
WaterJet Technology Association

# 2009 American WJTA Conference And Expo

August 18*-20, 2009 ● Marriott Houston Westchase Hotel ● Houston, Texas

## *Abstract Submission Form*

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 **January 15, 2009**. An electronic submission form can be found on the WJTA web site at www.wjta.org. Authors will be advised by **February 27, 2009**, regarding the decision of the Abstract Review Committee.

### Paper Information

Paper Title _____

Authors _____

### Contact Person

*(Please print or type)*

Name _____
(First Name) (Surname/Family Name)

Position/Title _____

Company/Organization _____

Street Address _____

City, Province _____ State _____

Country _____ Zip/Postal Code _____

Business Telephone _____ Fax _____

Email _____ Web site _____

Signature _____ Date _____

**Please check the category that best describes the general nature of your paper.** ❑ Applications ❑ Research

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

**Type of Study**
- ❑ Modeling
- ❑ Experimental study
- ❑ Hardware development
- ❑ Contractor case study
- ❑ Manufacturing case study
- ❑ Software development
- ❑ Economic analysis
- ❑ Legal and Safety
- ❑ Other _____

**Process**
- ❑ Cutting
- ❑ Drilling
- ❑ Surface preparation
- ❑ Cleaning
- ❑ Stripping
- ❑ Safety
- ❑ Milling
- ❑ Jet-assisted
- ❑ Other _____

**Related Industry**
- ❑ Generic
- ❑ Shipyard
- ❑ Mining
- ❑ Construction
- ❑ Aerospace/Aircraft
- ❑ Automotive
- ❑ Oil/Gas/Refinery
- ❑ Quarrying
- ❑ Other _____

**Jets**
- ❑ Waterjet
- ❑ Abrasive-waterjet
- ❑ Abrasive suspension jet
- ❑ Pulsed
- ❑ 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 short course(s).

Mail completed form and abstract, **NO LATER THAN JANUARY 15, 2009**, to: **Conference Coordinator, 2009 WJTA American Waterjet Conference, WaterJet Technology Association, 906 Olive Street, Suite 1200, St. Louis, MO 63101-1448, USA, telephone: (314)241-1445, fax: (314)241-1449, email: wjta@wjta.org, web site: www.wjta.org**

# WaterJet Technology Association's Order Form for Publications/Products

10-08

Name _____ Member # _____

Company _____

Address _____

City _____ State _____

Country _____ Postal Code _____

Phone # [ ]( ) _____ Fax # [ ]( )_____

Email_____

(to receive shipping confirmation)

**Billing Address** (if different from above):

Address _____

City _____ State _____

Country _____ Postal Code _____

**Payment Method**

❑ Check or Money Order payable to **WJTA** (U.S. DOLLARS ONLY)

❑ PO # _____ (Enclose PO)

❑ Please charge my ❑ MC ❑ VISA ❑ AMEX ❑ Discover

Credit Card # _____

Exp. Date_____/_____

_____

Print name as it appears on card

_____

Cardholder's signature

**THREE EASY WAYS TO ORDER**

**By Phone**: Just call **(314)241-1445** and have your credit card information ready. (MC/VISA/AMEX/ Discover ONLY).

**By Fax**: Fill out the order form with your credit card information and call our 24-hour fax number at: **(314)241-1449**.

**By Mail**: Fill out the order form and mail with applicable payment to: **WJTA, 906 Olive Street, Ste. 1200, St. Louis, MO 63101-1448.**

| | WJTA Member Price | Non Member Price | Shipping & Handling | |
|---|---|---|---|---|
| ____ **Proceedings CD-ROM of The 2007 American WJTA Conference And Expo** | @ $ 109.00 | $ 129.00 | $ 8.00 | = $_____ |
| ____ **Proceedings CD-ROM of The 2005 WJTA American Waterjet Conference** | @ $ 35.00 | $ 55.00 | $ 8.00 | = $_____ |
| ____ **Proceedings CD-ROM of The 2003 WJTA American Waterjet Conference** | @ $ 35.00 | $ 55.00 | $ 8.00 | = $_____ |
| ____ **Proceedings CD-ROM of The 2001 WJTA American Waterjet Conference** | @ $ 10.00 | $ 30.00 | $ 8.00 | = $_____ |
| ____ **An Overview of Waterjet Fundamentals And Applications,** Fifth Edition (2001) | @ $ 55.00 | $ 70.00 | $ 8.00 | = $_____ |
| ____ **An Overview of Waterjet Fundamentals And Applications** (8/17/03 PowerPoint presentations in printed format) | @ $ 30.00 | $ 35.00 | $ 8.00 | = $_____ |
| ____ **Waterjet Technology: Basics and Beyond** (8/19/07 PowerPoint presentations in printed format) | @ $ 20.00 | $ 25.00 | $ 8.00 | = $_____ |
| ____ **Waterjet Technology: Basics and Beyond** (8/21/05 PowerPoint presentations in printed format) | @ $ 20.00 | $ 25.00 | $ 8.00 | = $_____ |

**Minimum charge of $8 per order. $8 for 1-3 items purchased; $16 for 4-7 items purchased; for 8 or more items purchased, contact the WJTA office.**

❑ **Waterjet Equipment Recommended Safety Practices. *Specify:* ❑ English Edition or ❑ Spanish Edition**

❑ **Vacuum Equipment Recommended Safety Practices. *Specify:* ❑ English Edition or ❑ Spanish Edition**

| | | | |
|---|---|---|---|
| 1 - 10 copies _____ # of copies | x $ 7.00 ea. | $ 12.00 ea. | = $_____ |
| 11 - 99 copies _____ # of copies | x $ 6.00 ea. | $ 10.00 ea. | = $_____ |
| 100 - or more copies _____ # of copies | x $ 5.00 ea. | $ 8.00 ea. | = $_____ |

**Shipping & Handling of Recommended Safety Practices**

1-10 copies .... $0.50 per book, 11-99 copies ..... $0.40 per book, 100 - or more copies .. $0.25 per book ____ # of copies x $_____ = $_____

❑ **Waterjet Equipment Recommended Safety Practices Video. *Specify:* ❑ VHS Video or ❑ CDROM**

❑ **Vacuum Equipment Recommended Safety Practices Video. *Specify:* ❑ VHS Video or ❑ CDROM**

| | | | | |
|---|---|---|---|---|
| 1 - 4 copies _____ # of copies | x $ 49.95 ea. | $ 99.95 ea. | $ 6.00* | = $_____ |
| 5 - 10 copies _____ # of copies | x $ 39.95 ea. | $ 89.95 ea. | | = $_____ |
| 11 - or more copies _____ # of copies | x $ 29.95 ea. | $ 79.95 ea. | | = $_____ |

**Shipping & Handling of Safety Video** ..... = $_____

***Contact the WJTA office for the shipping & handling charge of more than one Safety Video.**

| | | | | | |
|---|---|---|---|---|---|
| **Baseball Cap** | _____ # of caps | x $ 7.95 ea. | $ 7.95 ea. | $ 6.00 ea. | = $_____ |
| **WJTA Decals.** Minimum $5 order includes shipping and handling. | | | | | |
| 5" decals 4 for $5, additional decals .50 each | _____ # of decals | | | | = $_____ |
| 3.5" decals 6 for $5, additional decals .45 each | _____ # of decals | | | | = $_____ |
| 2" decals 8 for $5, additional decals .40 each | _____ # of decals | | | | = $_____ |
| **WJTA Executive Organizer** | _____ # of organizers | x $ 20.00 ea. | $ 30.00 ea. | $ 8.00 ea. | = $_____ |
| **WJTA Navy Blue Polo Shirt** Size_____ (S, M, L, XL, 2X) | _____ # of shirts | x $ 30.00 ea. | $ 35.00 ea. | $ 7.00 ea. | = $_____ |

**Waterjet Safety Cards. *Specify:* ❑ English ❑ Spanish**

| | | | | |
|---|---|---|---|---|
| 1-10 safety cards | _____ # of cards | x .30 each | .50 each | = $_____ |
| 11-99 safety cards | _____ # of cards | x .25 each | .45 each | = $_____ |
| 100-249 safety cards | _____ # of cards | x .20 each | .40 each | = $_____ |
| 250+ safety cards | _____ # of cards | x .17 each | .35 each | = $_____ |

**Shipping & Handling of Safety Cards: 1-50 cards FREE** (For the purchase of more than 50, call the WJTA office for the shipping & handling charge.) = $_____

**For shipping and handling charges outside the USA, contact the WJTA Office.**

**TOTAL ENCLOSED** **$**

# Easy

## to operate • to maintain • to work with


**Jetstream waterblasting equipment is easy to operate and easy to maintain. More than that, our units, parts and accessories are backed by knowledgeable, approachable people who understand that our business is your business.**

"We always use Jetstream because they have less downtime and they are easier to work on. The people are knowledgeable and helpful. You tell them your problem, and they help you fix it. They'll even drill special nozzles for you."

*Steve Johnson, Division Manager*
*CCS, Longview, WA*

"They worked with us until the operation was up and running smoothly. With Jetstream's help, we finished what would have been a two-week project in six days."

*Charlie Underwood, Operations Manager*
*Midwest Waterblasting, Clinton, MI*

**It's easy to choose Jetstream.**

For more information or a demonstration call **1-800/231-8192** or visit **www.waterblast.com.**

©2008 Federal Signal Corporation, listed on the NYSE by the symbol FSS.

Jetstream®
Subsidiary of Federal Signal Corporation