WJTA Jet News

WaterJet Technology Association

APRIL 2004

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

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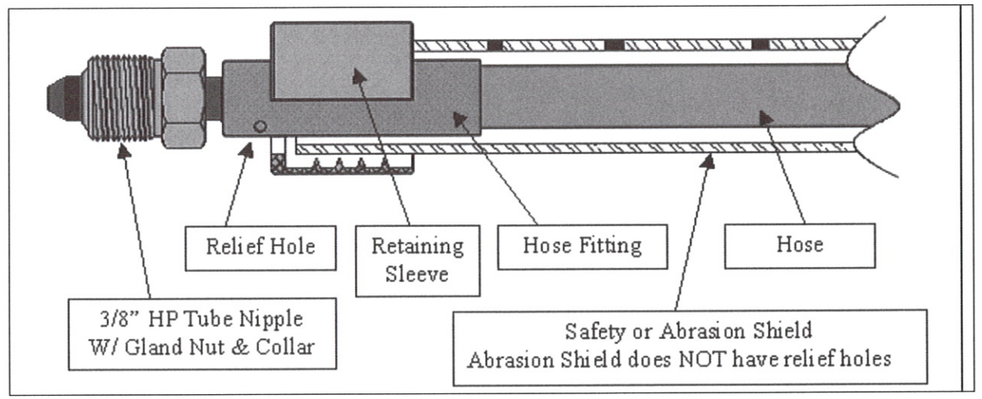
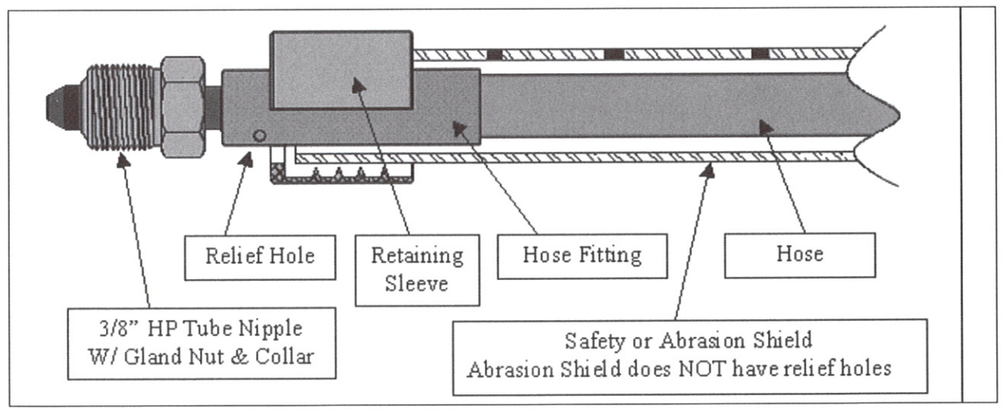
High Pressure Hose



Basic design of a 40,000 and 55,000 psi hose assembly with safety (burst) shield and stiffener.



Basic design of a 40,000 psi hose assembly with safety or abrasion shield without stiffener.

See article, "Recommended Practices for the Use of High Pressure Hose," on page 2.

Recommended Practices for the Use of High Pressure Hose

By: Paul Webster, Stephen Johns
Parker Hannifin Corp., Polyflex Business Unit, Houston, Texas

ABSTRACT

Ultra High Pressure (UHP) hoses are a key component in today's water jetting systems. This paper will present field practices to assist the user in maximizing hose life, determining when a hose should be replaced, along with presenting manufacturing techniques and accessories used to build a safe and reliable product. Many external factors can decrease the life expectancy of a hose assembly. The continued advancement in fitting and hose development enhances connection technology and service life. The use of accessories, including but not limited to bend stiffeners, safety shields, abrasion shields, and containment grips can substantially add to the service life while providing increased safety measures. Daily inspection of hose assemblies is critical to operator safety. Photos of damaged hose, examples of safety devices and test results are included in this paper.

1. INTRODUCTION

Today 55,000 psi water jetting equipment is fast becoming a reality; therefore, it is more important than ever to follow safety guidelines and practices that extend the life of the high-pressure hose. Working pressures are much higher than 10 years ago when 40,000 psi equipment first became available. Advances in manufacturing techniques and the use of accessories have dramatically increased the life of the hose. Flex lances will also be specifically addressed, since they require the greatest adherence to safety due their close proximity to the operator. This paper will describe:

- Market Trends; The Development of UHP Hose
- Factors that Reduce Hose Service Life
- Practices that Increase Service Life
- UHP Hose Safety
- Evaluation of Hose for Service
- Conclusion
- Illustrations

2. MARKET TRENDS; THE DEVELOPMENT OF UHP HOSE

During the early 1980's the hydraulic tool industry developed equipment that "pushed the envelope" of technology and accessories to support this industry. The hydraulic hose, being one of these accessories, was not capable of handling the requirements required by this equipment. Dr. John Rogan, an entrepreneur for a product line of bolt tensioners realized the need for a new hose that offered higher operating pressures, increased impulse life and most important lower volumetric expansion that would allow for faster cycle times of the equipment. This state of the art thermoplastic hose exceeded the current market offering. Soon after, Dr. Rogan was supplying hoses not only for his own equipment but realized the market needs for other industry applications, including water blasting, high pressure test equipment replacing steel tubing, and chemically resistant hose for the oil & gas industry. As a result, the UHP hose industry was born.

This 'new hose' now commonly referred to as UHP hose was based on a thermoplastic core tube reinforced with very high strength steel wire and jacketed with a thermoplastic outer cover. The performance capabilities of a UHP hose are the result of proprietary methods where the wire reinforcement is "spiralized" onto the core tube. This precise spiralization process allows the hoop stress to be equally distributed throughout the high strength reinforcing layers permitting the hose to function at higher pressures with minimal volumetric expansion and axial movement.

The water blasting industry has been the driving force of hose manufacturers and UHP equipment over the last three decades. The 1980's forced manufacturers to develop what some would now consider low-pressure equipment. In the early 1990s, pressures increased to 36,000 psi and then 40,000 psi in the later part of the decade.

Historically, an increase in equipment pressure requirements was followed by an increase in flow rates. Thus, a 36,000 psi hose would be developed with a 3/16" ID, then a 3/10" ID and today a ½" ID, 36,000 psi hose is available. In the year 2000, working pressures approached 45,000 psi with new pumps in development designed to operate at 50,000 and 55,000 psi. It has been quite a challenge for manufacturers to develop technology and design equipment because of the stresses exerted on materials at these elevated pressures. In the future, water-jetting pressures may reach 60,000 psi to 65,000 psi; however, significant R&D expenditures will be required in material science, as current practices are reaching their design limits.

3. HOSE ASSEMBLY MAKEUP

3.1 UHP Hose with Safety Shield

In figure 1, a typical UHP hose is shown with a 3/8" high-pressure (HP) tube nipple fitting. The important features illustrated are the stiffener, the safety or abrasion shield and the relief sight holes in the fitting, swivel nut and stiffener. The safety shield

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7. EVALUATION OF HOSE FOR SERVICE

Make it standard practice to inspect the UHP hose prior to use. If the assembly is equipped with a burst shield, make sure it has not pulled off of the fitting or out of the stiffener exposing the hose. Look for indications of leaks at relief holes. If the hose has an abrasion shield, inspect for areas that are worn through exposing the hose to abrasion. These areas can be repaired inexpensively. Refer to section 5.4 for quick solutions that can prevent further abrasion. In the case of flex lances, look for exposed wires. This is a serious condition and demands immediate removal from service. Check if the cover is wrinkled behind the fitting, which indicates a kink. Also look for kinks and crushed areas along the length of the flex lance. Inspect the fitting for damage. It may be oval from improper assembly or the waterjet has begun to wear away the fitting. Check for stiff sections along the length of the hose. This indicates the area is corroded and the hose must be discarded at once. Check the age of the hose assembly. If its age cannot be determined it is safer to not use the flex lance than to risk possible failure.

8. CONCLUSION

Since the initial development of high-pressure hose, many technical advancements have been made. The core tube materials are much tougher, have improved fatigue resistance and new manufacturing methods produce tube of consistent quality. The quality and tenacity of the pressure carrying reinforcement has improved dramatically. This makes for a longer service life and higher rated burst strength. Hose fittings have been engineered to avoid leakage thereby increasing service life. Given these advancements, the end user can expect the same level of performance from each and every hose assembly. Outer covers are tougher and offer greater abrasion resistance and may be extra thick, which may eliminate the need for abrasion shields. These special covers are becoming standard on many of the large bore hoses and have multi-layer covers of different colors. If the outer cover is worn down to the sub-layer then the color change is evident and added protection or hose replacement can be addressed at this point. Further study in chemical attack is planned, as are lighter safety shields. Manufacturers are investing in R&D to increase flow and pressure ratings in larger hose types, which are used as supply hoses. On going technical improvements include, chemical compatibility, weight reducing polymers, increased hose flexibility and higher working pressures. Finally, safety is of utmost concern and manufacturers are actively improving and developing new accessories that will protect the operator and offer a safe product that can be used with the highest confidence.

Coating Removal Service Expands To Miami

Advanced Systems Technologies, Inc. (AST), a unit of Pratt & Whitney's Specialty Materials and Services division, has opened a new Coating Removal Service Center in Miami, Fla. This is the first service center of its kind in Florida and the sixth North American facility for AST, which is based in Huntsville, Alabama.

"There are businesses in Miami that don't have the resources or the volume of parts to justify purchasing their own advanced waterjet system but have a need for the process," Manager of Business Operations Jim Cooper says. "At this service center, their parts in just about any size or material can be conveniently processed with a quick turnaround."

AST uses a patented, environmentally friendly robotic-controlled process that utilizes ultra-high pressure water as the removal medium, without abrasive additives. The waterjet stripping process does not damage the base material, including out-of-round parts or on contoured surfaces and is ideally suited for simple or complex geometry surfaces.

This process, the cornerstone of AST's Green Initiative, allows for difficult coatings to be removed without machining or use of chemicals. This includes Thermal Spray Coatings, Ceramics, Plastics, Rubber, Silicone and Epoxy/Paints. Typical uses for the technology employed at the Miami facility include coating removal for overhaul, new manufacturing rework and contaminant-free surface preparation.

AST is an approved source in the aircraft industry specifically designated in major original equipment manufacturing (OEM) operating procedures. Service is offered to all industries, and AST helps companies become more versatile, productive and have a competitive edge.

The new facility joins AST Service Centers operating in Huntsville, Alabama.; San Antonio, Texas; East Hartford, Connecticut.; Montreal, Canada and North Berwick, Maine. The company plans to further expand its operation base.

AST also manufactures systems, and provides coating services, utilizing CST ® a breakthrough, fully-automated convergent spray coating technology that can eliminate solvents and enable high-speed coating deposition for a vast range of solid filler particles, including rapid-curing and non-mixable components.

AST is a wholly owned subsidiary of United Technologies Corporation (NYSE: UTX). Pratt & Whitney, a UTC company, is a world leader in the design, manufacture and service of aircraft engines, space propulsion systems and industrial gas turbines.

Visit AST online at www.pwast.com and www.wjs.com/sercenter.html or contact Jim Cooper, manager of business operations, at (256) 721-2426.

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may also be referred to as a burst or containment shield. The safety or containment shield is designed to resist a hose burst or pinhole leak at the rated working pressure and offers abrasion resistance to protect the hose from external damage. The stiffener is used to prevent the hose from bending directly behind the fitting, which decreases the stress at the hose/fitting interface. The relief hole is a leak indicator and offers some protection from pressure build up within the fitting or threaded connection. In figure 2, the abrasion shield is clamped directly onto the hose fitting using a retaining sleeve. With the safety shield attached in this manner, additional pressure relief holes are added to the shield to relieve any pressure build up and indicate leakage.

3.2 UHP Hose with Abrasion Shield

Cuts, tears and punctures are common sources of abuse causing premature hose failures. An abrasion shield is a flexible thermoplastic cover designed to prevent these common causes of hose damage. In figure 2, an abrasion shield like the safety shield, is clamped directly onto the hose fitting using a retaining sleeve. An abrasion shield does not have relief holes to vent pressure build up nor does it offer operator protection from high-pressure fluid leakage.

3.3 Flex Lance

Figure 3 illustrates a typical flex lance. Flex lances are rated from 10,000 psi to 30,000 psi. The flex lance fitting is commonly called a 'ProLance™' fitting. These are a one-piece welded design and may or may not have a hex. Their short length and small OD profile allow easy passage through small ID tubes found in heat exchangers, P-traps and chemical processing tubes. Flex lances have a tough outer cover and may also have an additional outer stainless steel braid for extra abrasion resistance. In the absence of a fitting hex, the user must grip onto the outside of the hose fitting to attach a nozzle, adapter or stinger, which if done improperly will compromise the integrity of the fitting and hose assembly. Guidelines for attaching jetting components to the hose fitting are covered in section 6.4.

3.4 Hose Fitting Types

UHP fittings come in many connection types and sizes. Illustrated in figure 4 is a 3/8" high-pressure tubing nipple and a Type M fitting. High-pressure tube nipples use a gland nut and collar arrangement. A better gland nut & collar configuration is the anti-vibration type, which prevents the tube from fatiguing at the thread root and the metal-to-metal seal from fretting, cracking and then leaking. The European style high-pressure tubing, gland nut and collar, use metric threads rather than unified threads (UN) found in North America. The Type "M" profile is available in all hose sizes and working pressures up to 55,000 psi. The swivel nut has an internal thread and also protects the male cone so neither can become damaged. The Type M fitting also eliminates the problem of external thread failure common with tubing nipples. The European Type M equivalent uses a metric or a BSPP thread (British Standard Parallel Pipe). Illustrated in figure 5 is the DIN 20 (heavy series) fitting, which is more popular in Europe and Asia.

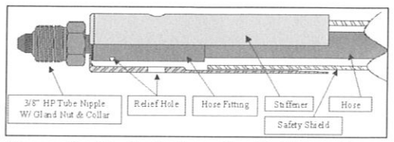

Figure 1 - Basic design of a 40,000 and 55,000 psi hose assembly with safety (burst) shield and stiffner. (Also, pictured on the cover.)

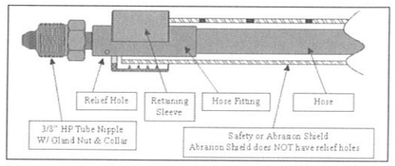

Figure 2 - Basic design of a 40,000 psi hose assembly with safety or abrasion shield without stiffner. (Also, pictured on the cover.)

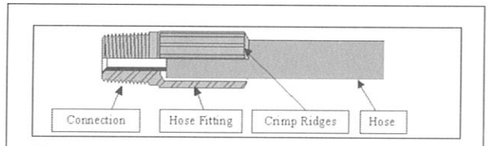

Figure 3 - Basic design of a 10,000 through 30,000 psi flex lance with ProLance™ fitting.

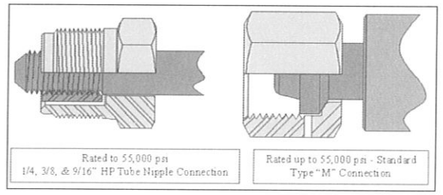

Figure 4 - Basic design of High Pressure (HP) Tube Nipple and Standard Type "M" Fitting.

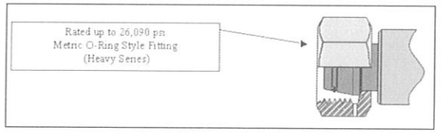

Figure 5 - Basic design of European Style DIN 20 (heavy series) Metric O-Ring Fitting

This fitting has a 24-degree male cone with an o-ring and metric swivel nut. These are rated up to 26,090 psi. NPT threads ½" and smaller are typically

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Welcome WJTA New Members

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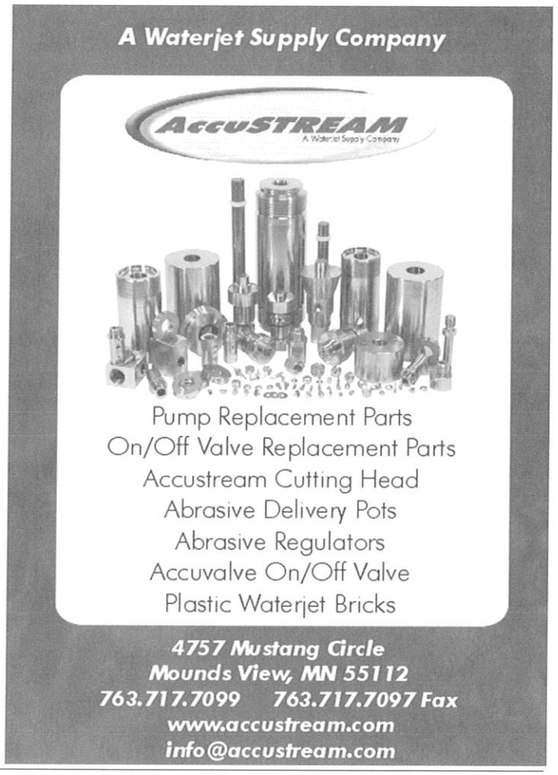

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6.2 Containment Grips, Support Grips and Bend Restrictors

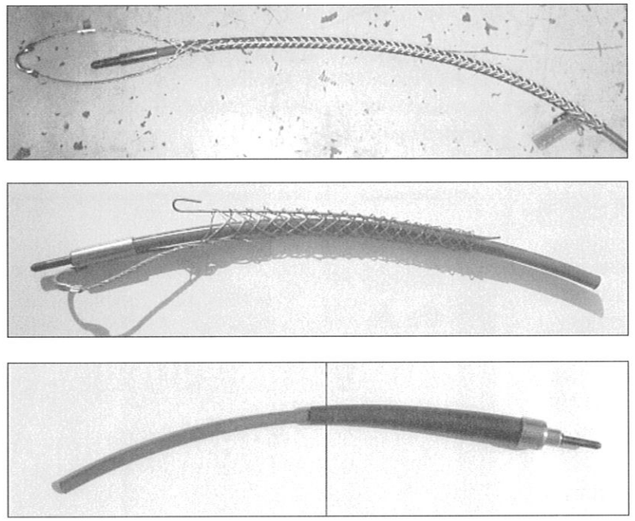

Figure 12 - The top photo shows a containment grip, the middle shows a support grip and the bottom photo shows at bend restrictor. All accessories shown are designed for UHP Hose.

Containment grips are used to reduce hose "whipping" in the event the hose separates from the fitting under pressure. Additionally, it can act as a support grip. Containment grips bite into the hose as the grip is pulled. The harder the grip is pulled, the tighter it grips the hose. In laboratory tests, the containment grip can crush the hose if pulled with enough force. Like the safety shield, the containment grip must be properly rated to the hose by specifying its breaking strength. For example a ½" ID, 20,000 psi working pressure hose produces a 15,708 lb. end load. A 1.25 design margin is typically used in rating a containment grip; therefore, a breaking strength of 19,635 lbs. is required for the above example.

Support grips are much shorter and have a lower breaking strength than containment grips. They are used to support the weight of the hose assembly such as a hose hanging from scaffolding. They should not be expected to contain whipping of the hose assembly.

Bend restrictors are used to prevent the hose from bending behind the fitting. These are different from the stiffeners illustrated in figure 1. Bend restrictors are semi-ridged and allow the hose to bend gradually. They typically do not offer burst protection. Containment grips, support grips and bend restrictors are shown in figure 12.

6.3 Relief Holes

UHP hose fittings, high pressure adapters and even some quick connect couplers have relief holes. Relief holes are used principally as a leak indicator and to vent fluid leakage. If the leaking fluid is not vented, then pressure may build up in the connection and may cause separation. Relief holes are found on Type M swivel nuts, female high-pressure ports, all large bore UHP hose fittings and 40,000 through 55,000 psi hose fittings. Refer to figure 1 for examples of relief holes. In the case of a swivel nut or a gland nut & collar assembly, simply tightening the fitting may stop the leak. If the male or female cone is too far damaged or worn, then no amount of tightening will stop the leak. At ultra high pressures, even a microscopic leak will quickly wear and become enlarged to the extent that the relief hole may not be able to fully dissipate the fluid and pressure. It is strongly recommended that if a leak is observed at a relief hole, replace the part at once.

6.4 Flex Lances

Flex lances are specifically addressed in this paper due to their close proximity to the user. Reiterating what has already been presented; the most common point of fluid loss is at the fitting. The hose may become kinked or the outer cover is worn away and the wire reinforcement becomes corroded. Corrosion may account for a loss of ° the hose's rated burst strength given a design factor or 2.5 to 1 (given the burst pressure is 2.5 times the working pressure). Due to the nature of flex lance fittings and their one-piece design, there is no hex or parallel flat to grasp onto to tighten the nozzle, adapter or stinger. Therefore, the common method is to use vice grips, a vise, or a pipe wrench to hold the fitting. Although it is very infrequent, squashing the fitting oval is possible and it is suggested that the user examine the fitting for possible damage after installing the nozzle or adapter. Measure the roundness of the fitting. It should not be out of round more than .010"

The use of tube lancing machines for cleaning tube bundles has become fairly common today. This moves the operator away from the lance and waterjet. Several manufactures offer mechanized lancing machines that increase operator safety, increase the life of the flex lance and are often more productive.

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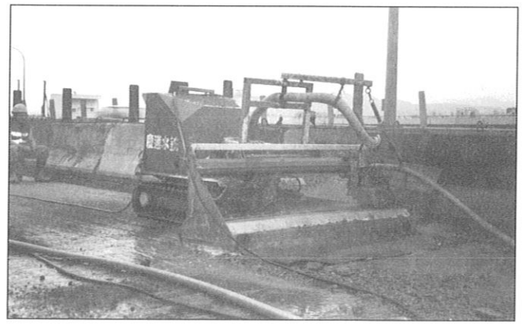
Hydrodemolition Projects

Hydrodemolition on Bridge Deck in Taipei, Taiwan



Hydrodemolition creates a greater bonding area for new concrete surface and removes micro cracks on the Da-Jur Bridge in Taipei, Taiwan (see photo at right).

A hydrodemolition system supplied by Aquajet Systems AB of Sweden played a key role in the USD7.4m refurbishment of the Da-Jur Bridge in Taipei. The system, comprising a high pressure Power Pack 480 (PP-480) with a WOMA 480Z pump, and Aqua Cutter H-450 robot, was used to remove the delaminating and cracking concrete deck surface of the 20-year-old bridge.

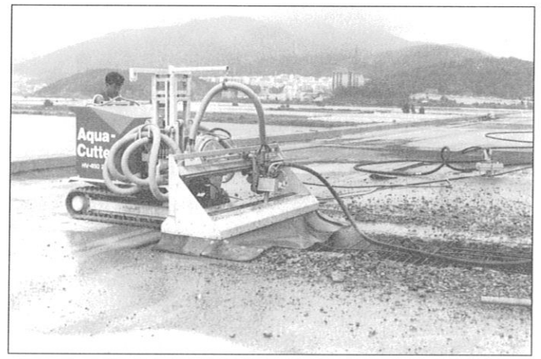
Working in four phases over a total of 112 days, hydrodemolition specialist Hi Tech Hydro Services Corporation removed 29,676m^2 (319,440 ft^2) of material to an average depth of 5cm (2 in). The hardness of the concrete varied from 28Mpa (4000 psi) on the deck surface to 42Mpa (6000 psi) at the joints. To facilitate removal of the joints and expose the steel, the concrete was cut to a depth of 15cm (5.9 in), 20cm (7.9 in) before and after each joint.

This hydrodemolition system, which can deliver 193 l/min at a working pressure of 1000Bar (14500 psi), created a 'craggy' surface that provided a greater bonding area than would have been possible using conventional impact tools. The system also removed all micro cracks from the remaining surface, much to the relief of concrete supplier, Densit Corporation of Denmark.

The new surface is an 83Mpa (12,000 psi), steel and polypropylene fibre reinforced concrete.

The bridge refurbishment, including the removal and replacement of all pre-stressed concrete beams took a total of just 292 days.

Hydrodemolition on Road Bridge In Pusan, Korea



Aquajet Systems AB hydrodemolition technique provides a fast and vibration-free solution for refurbishment of a 40-year-old bridge in Korea.

When investigations revealed that around 1150m^2 of concrete deck on an important river bridge crossing in Pusan needed replacing, the Korean Highway Corporation had no hesitation in specifying hydrodemolition for the repair and refurbishment program.

Built around 40-years ago and measuring approximately 1340m long x 12m wide, the Nak-Dong Bridge has a 200-280mm thick deck supported on three parallel steel I-beams, each with a span of approximately 77m. Vibrations from impact tools would not only spoil the bonding of the concrete deck to the I-beam but also the rebar bonding in the remaining concrete. It could also cause mechanical damage as marks and cracks in the steel beams and bending and destroying of reinforcement.

The Sung-Do Demolition Engineering Company used two of their Aquajet Systems AB Aqua Cutter Hydrodemolition units to remove completely the damaged concrete. Deterioration was located on different sections of the bridge, with the larger areas measuring up to approximately 50m^2.

The refurbishment project followed the construction of a second two-lane bridge, parallel to the original.

Hydrodemolition at Seawater Injection Facility in Saudi Arabia

A hydrodemolition system supplied by Aquajet Systems AB has helped contractors working on a canal refurbishment project in Saudi Arabia to remove around 500m^3 of concrete in just 10 months.

The 225m long canal feeds the Qurrayah seawater treatment plant, which in turn supplies a Saudi Aramco oil production facility.

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Hydrodemolition Projects, from page 6

The structure was in a critical condition, with leaking construction joints and deterioration, delamination, spalling, corroded reinforcement and cracking visible throughout the concrete structure. However, since the water supply is an integral part of the oil production process, any repair work had to be done without closing the canal completely.

The 225m long canal, measuring approximately 4.8m high x 12m wide, has 380mm thick walls and holds approximately 3 million gallons of water. The flume to the sea is 478m long x 4m wide and varies in height from 1.6m to 2.6m. Its walls are 300mm thick.

Hydrodemolition specialist Saudi Hydrodynamics had to remove approximately 500m^3 of concrete using a combination of an Aqua Cutter HV-450, two Aqua Frames and two PP-480 Power units. The challenge was to expose the reinforcing bars, leaving a space behind the bar.

The compact and versatile Aqua Frames were ideally suited to the project, where there was only approximately 700mm of space available between the canal wall and the pipeline beds along both sides of the entire structure.

The first stage of the project began with the top rim of the canal wall. Specially designed scaffolding allowed the HV-450 robot to move on its tracks along the interior of the canal. Special platforms also had to be manufactured to ensure no debris could enter the canal water source. The top rim was also cast in situ, rather than shotcreted.

The second phase included removal of concrete from the walls of the canal. To maintain structural integrity, this had to be done in alternate 2m sections. A shotcreting team applied the replacement concrete to the exposed rough surface using a 'wet' technique. The concrete mix was then left to cure for 14 days.

Saudi Hydrodynamics also had to repair approximately 300 linear metres of concrete cracking with injected epoxy resin.

For further information, contact: Stefan Hilmersson, Aquajet Systems AB, Brunnsvägen 15, SE-570 15 Holsbybrunn, Sweden, Tel: int +46 (0)383 508 01, Fax: int +46 (0)383 507 30, email: aquajet@aquajet.se, web site: www.aquajet.se

Conjet Wireless Control Unit

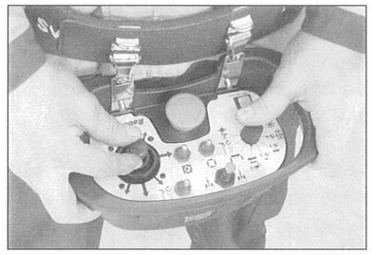
Conjet AB launched its wireless control unit for the Conjet Robot 322 and Conjet Robot 432D hydrodemolition machines at the Bauma 2004 Exhibition held March 29-April 4, 2004, at the new Munich Trade Fair Centre, Munich, Germany. The wireless control unit has the advantage of allowing the robot operator to move freely without being obstructed by a normal control cable. The unit has been designed to provide enough reach for all possible hydrodemolition applications. If the robot loses contact with the remote wireless control unit, the emergency stop is automatically activated and the robot and the pump will shut down.

The remote wireless control unit is powered by standard mobile phone batteries. The charger, which is supplied with the wireless unit, can be powered from the main supply or from the 12-24 Volt DC outlet on the robot. There are currently two versions of the radio control unit to cater to the different radio transmitting regulations in the European and American markets. The wireless control unit is available as a retro fit option for the Conjet 322 and Conjet 432D and is very easy to install. The receiver/transmitter is placed under the Robot's cover and connected to the machine's standard remote control socket and the unit is ready for operation in seconds.

In addition to the wireless control unit, Conjet displayed its latest Conjet Robot 363 MPA with multi-positioning arm and Conjet Robot 322 hydrodemolition machines. The larger Conjet Robot 363 MPA is a compact, exceptionally maneuverable, self contained, four-wheeled hydrostatically driven concrete removing hydrodemolition robot with a multi-positioning arm (MPA). The arm is mounted on a 360º rotating turntable on the front of the base carrier to provide a reach of over 6m. The versatile MPA gives the operator considerable flexibility to use the Conjet Robot 363 MPA on a wide variety of hydrodemolition tasks, including reaching up into tunnel crowns or under a bridge deck soffit while the machine stays on the deck above.

The Conjet Robot 363 MPA is complemented by the Conjet Robot 322, a remotely operated hydrodemolition robot, which is compact, light, exceptionally maneuverable and ideal for working in confined spaces and areas inaccessible to larger equipment. It is very narrow and can pass through a 0.8m to 1m wide opening, depending on attachment tool, making the Robot 322 ideal for operating in tunnels as small as 1.7m diameter with rotor attachment, culverts, inside concrete box girder bridge decks and under bridge and quay decks. The Robot 322 is also exceptionally efficient for use in numerous industrial-cleaning applications and has been designed to operate with existing 134hp to 470hp (100kW to 350kW) diesel driven high-pressure pumps feeding water to the jetting nozzle.

The Robot 322 is easily adaptable to take a variety of hydrodemolition tools. It also enables hydrodemolition contractors to mechanize and replace the far less efficient and less productive hand lancing and jack hammering techniques. Hand held methods are known to be exceptionally tiring, stressful, noisy, and dangerous for operators. Removal of concrete with a jackhammer or hand lance is also much slower than and not as selective as a robot. In addition hand lances are very inefficient with their use of water and need far greater quantities than more



effective and environmentally friendly robots to remove a specific amount of concrete.

Conjet AB designs, develops and manufactures high-pressure waterjetting hydrodemolition equipment for removing damaged concrete. For more information, contact Lars-Göran Nilsson or Carl Strömdahl, Conjet AB, P.O. Box 507, S-136 25 Haninge, Sweden, Tel: + 00-46-8-5565-2240, Fax: + 00-46-8-5565-2260, E-mail: conjet@conjet.com, web site: http://www.conjet.com

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

Jet Edge Intensifier Pump

Jet Edge continues to expand its line of 55,000 psi (3800 bar) ultra-high pressure (UHP) waterjet equipment for cutting virtually any metallic or non-metallic material. The newest addition to the Jet Edge product line is the Model 55-50C intensifier pump featuring a patented intensifier design combined with an attenuator, complying with ASME pressure vessel standards, to minimize pressure fluctuations. A 50-horsepower motor drives an axial piston, variable displacement, pressure-compensated type hydraulic pump.

The new Jet Edge pump incorporates 20 years of knowledge of hydraulics and high pressure water to deliver the most efficient 50 horsepower intensifier available in the industry. The Model 55-50C will support two (2) 0.011" orifices or one (1) 0.016" orifice - no other 50 HP pump in the industry can match its performance.

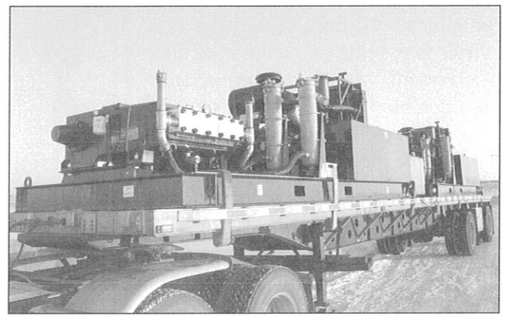
The hydraulic system uses an electronically shifted, plunger-style single intensifier to deliver 1.1 gallons (4.1 liters) per minute of 55,000 psi water flow to a variety of cutting or cleaning tools. The high efficiency, totally enclosed, fan cooled (TEFC) electric motor with wye-delta "soft start" ensures high reliability, long service life and minimal energy usage. A programmable logic controller (PLC) monitors and controls all machine functions, and automatically energizes relays to light the warning lamps in the event of potentially damaging conditions. The integrated water filter and booster system eliminates connections between other filtration systems.

The Jet Edge Model 55-50C, like other UHP intensifier pumps in this expanding line, offers complete flexibility for waterjet cutting, cleaning or coating removal applications.

For more information, contact Jet Edge, 12070 43rd Street NE, St. Michael, MN 55376, toll-free phone: 1-800-JET EDGE, web site: www.jetedge.com

Jetstream Introduces 500-Horsepower Waterblaster

Continuing a tradition of user-friendly innovations, Jetstream introduces a 500-horsepower waterblaster. This represents the highest power rating in the Jetstream line, which had previously been available up to 300 hp.



Jetstream introduces a 500-horsepower waterblaster, the highest power rating in the Jetstream line. The 500-hp pump delivers up to 20,000 psi for applications where high pressures and high-volume flows are needed for optimum cleaning.

The 500 hp quintuplex pump delivers a maximum of 20,000 psi for applications, such as boiler washing and stack cleaning in power plants, where high pressures and high-volume flows are needed for optimum cleaning. Flows range from 40 gpm at 20,000 psi to 100 gpm at 8,000 psi.

The 500-hp unit is available in PTO or transmission drive.

"With 500 horsepower, we've increased the flow to handle tougher jobs, while still delivering the same ease of use and convenience that Jetstream is known for," says Tony Fuller, national sales manager for Jetstream.

Jetstream manufactures industrial high-pressure waterblasting equipment operated at pressures up to 40,000 psi for a wide range of industrial cleaning and surface prep applications. Product offerings include a complete line of skid- and trailer-mounted pump units, control guns, valves, hoses, replacement parts and nozzles.

Jetstream products provide these distinct advantages:

- **Pressure convertibility:** The operator can convert a unit to 10,000, 20,000 or 40,000 psi in the field with minimal tools in minutes, not hours.
- **Ease of maintenance:** Jetstream pumps and replacement parts deliver easy maintenance and enhanced productivity. With the patented UNx™ design pump, preventative maintenance and valve replacement are easy. Jetstream's cartridge-style design allows for easy replacement, bringing control guns and UNx™ fluid ends back to like-new condition. In addition, Jetstream's experienced on-staff consultants are Solutions Providers, delivering flexible solutions to meet customer needs.

For more information, call 1-800-231-8192, or visit Jetstream on the Internet at www.waterblast.com.

— Classified —

Florida-based individual with 33 years of industry experience seeks a position to utilize supervisory, managerial and operational skills in waterjet cleaning, coating and paint removal, hydrodemolition, and ultra high pressure abrasive cutting. Holds a Class A CDL and is also skilled in carpentry, plumbing, welding, electric, and heavy equipment operation. Willing to travel. Resume available upon request. Contact William G. Smith at (772)336-9907.

ground or against objects in the operating environment. As previously mentioned, prevention of cover abrasion is critical to hose life. New hoses coming onto the market may have two layers of dissimilar colored covers. When the outer cover is worn down to the sub-layer, the color change becomes evident and immediate action can be taken to prevent further abrasion. Several accessories offer additional protection to the hose cover. Abrasion shields are commonly installed on the hose at the factory to prevent abrasion. Nylon spiral guards, which can be applied in the field, are especially good at preventing initial abrasion or stopping further abrasion once it has begun. Other types of shields can be wrapped around the hose and secured with tie wraps for localized abrasion resistance. Ask your hose supplier what abrasion accessories are available for the hose you are using.

6. UHP HOSE SAFETY

6.1 Safety Shields

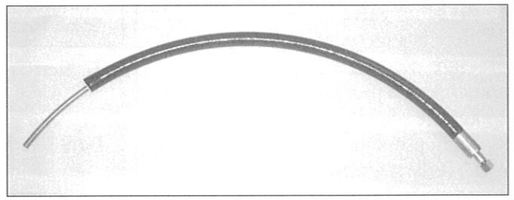


Figure 11 - Hose is shown with whip check as opposed to a full-length safety shield.

As discussed already, safety shields are used to protect the user in the event of a hose fluid leak. In many cases, inadequate shields are used on UHP hoses or abrasion shields are expected to provide operator safety from a high-pressure fluid leak. A properly rated shield will resist a burst and the resultant waterjet at the system's rated working pressure. A safety shield can run the entire length of the hose assembly or it can be a short five to six foot whip that is affixed to one or both fittings. A whip may also serve as a bend restrictor lessening the bending moment behind the fitting. Figure 11 shows a whip being used as opposed to a full-length safety shield. Abrasion shields offer no resistance to a hose burst and are only used to protect the hose from abrasion. Never let the hose come in contact with the any part of the body unless a safety shield is installed on the hose assembly. Make sure the equipment manufacturer has approved the safety shield based on the hose size and working pressure. Do not use an un-approved safety shield or protective shields that have pulled away from the fitting exposing the hose.

(continued on page 16)

rated at 15,000 psi and ¾" NPT and above are rated at 10,000 psi. Check with the manufacturer and verify the pressure rating of their adapter or fitting since the strength of the material governs the pressure carrying capabilities. Not all are rated to the same pressure even though the thread form and geometry appear to be similar.

4. FACTORS THAT REDUCE SERVICE LIFE

4.1 Hose Fitting Stress

The most common type of damage is at the fitting since this is the weakest point of the hose assembly. Stiffeners are installed on the hose assembly to reduce the bending moment directly behind the fitting, which reduces stress at the hose and fitting interface and prolongs assembly service life. See figure 6. A stiffener keeps the hose straight behind the fitting and the safety shield acts as a semi stiff bend restrictor to let the hose gradually bend. A general rule of thumb is to keep the hose supported and straight directly behind the fitting for a minimum length of 3 times the hose OD. Figure 7 illustrates a hose attached to a gun in a manner that creates a bending stress at the fitting. Another type of stress at the fitting is axial loading where the hose assembly is stretched or compressed at the fitting. Two cases are given as examples. In the first case, the hose assembly is hanging from scaffolding and stretches or tensile loads the hose at the topside fitting. In the second case, a hose assembly is attached along its length to a cable or other vertical fixture by the use of a tethering device; however, the tethering device slides on the support letting the hose fitting support the weight of the hose and tethering components. Refer to table A for an example of the decrease in service life in these cases.

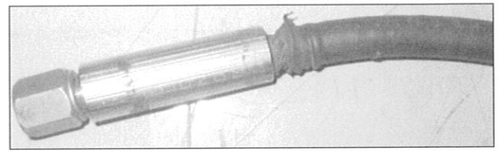


Figure 6 - Kinked 40ksi Hose. The hose was supplied with an abrasion shield only. A stiffener or bend restrictor was not used. Note the wrinkled outer cover directly behind the fitting.

4.2 Abrasion

Abrasion is regarded as damage to the outer cover and underlying reinforcement. When the outer cover becomes abraded to the extent that the reinforcement is visible, the environment will cause degradation and the reinforcement becomes the acting wear member. All reinforcing layers whether steel or fiber contribute to the strength of the hose. If the reinforcement becomes degraded, hose life will be reduced. The hose should always be visually examined prior to use for signs of abrasion. Refer to figure 8 for an example of a badly abraded flex lance.

4.3 Kinks & Crushes

Kinks and crushes are due to mishandling and improper installation. Several scenarios cause kinking. Dragging the hose around a sharp corner or pulling the hose when it is in a coiled state and not letting the hose naturally un-twist may cause the hose

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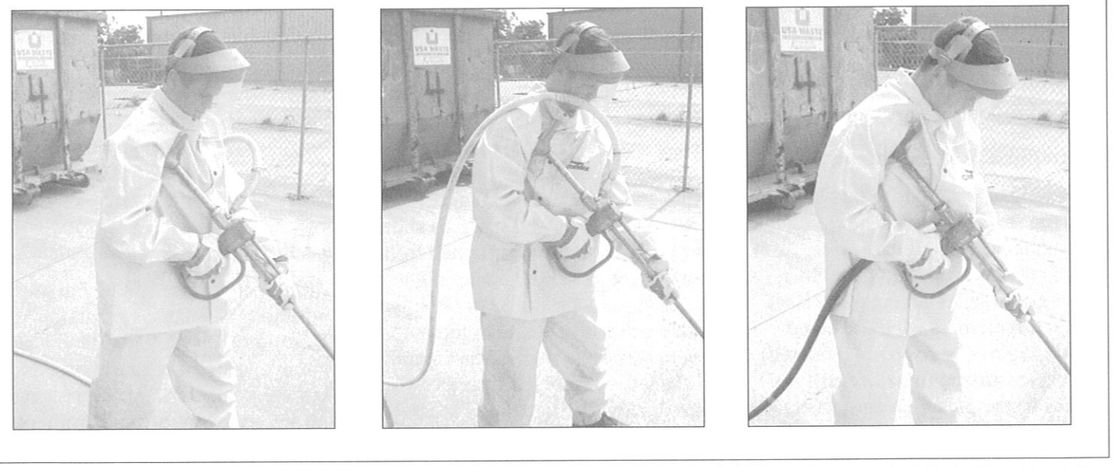

Figure 7 - First two photos show a hose attached to a gun without a burst shield and the hose is stressed at the fitting due to it being attached to the gun improperly. The last photo (far right) shows a UHP hose with a burst shield, stiffener, and is properly attached so the hose is not bent at the fitting.

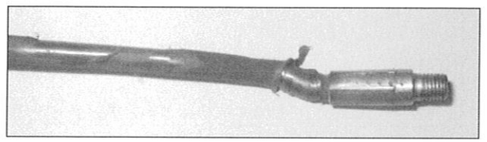

Figure 8 - Flex Lance kinked, wires damaged, and outer cover is worn away.

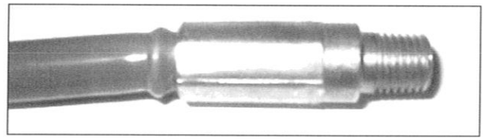

Figure 9 - Flex Lance behind fitting. Note the wrinkled outer cover.

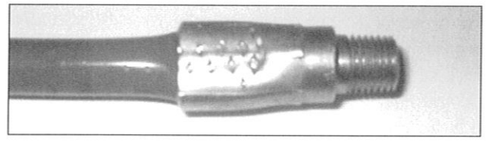

Figure 10 - Flex Lance with Squashed ProLance™ Fitting.

to kink. With a safety shield or abrasion shield, damage is not easily detectable. Crushes may occur if heavy equipment is dropped on the hose assembly or if special clamping accessories are improperly attached to the assembly. Crushes are visibly detected as oval, flattened areas along the length of the hose. Both kinks and crushes will significantly reduce service life or may lead to immediate failure when pressurized.

4.4 Impulse & Flex Fatigue

Hose fatigue is similar to that in high-pressure steel tubing and adapters. The main component that causes hose fatigue is pressure cycling and to a lesser extent hose flexing. The steel wire reinforcement is cold worked every time it is pressurized (stressed) and depressurized (un-stressed). Pumps where pulsation dampeners are not used cause the hose to expand and relax at very high frequencies. The magnitude of pressure change has the most affect on hose reinforcement fatigue since the wire is stressed and un-stressed to a greater degree. If the pressure is constant and offers very little cyclical pulsation, hose service life will increase. High frequency flexing will cause the wire reinforcement to fatigue; however, these cases are very rare and only occur in applications where the hose is under constant flexing. High frequency flexing of UHP hose should be avoided.

4.5 Flex Lance Damage

Flex lance applications demand extraordinary caution due to operator proximity to the waterjet. By far the most common failure is, again like the UHP hose, caused by damage at the fitting and hose interface. Figure 8 shows a typical lance presented for evaluation. The outer cover is missing, the hose is kinked at the fitting and the steel reinforcement is severely damaged. Figure 9 shows a wrinkled outer cover at the fitting. This is a clear sign that the hose assembly has been 'kinked' behind the fitting and should be immediately taken out of service. Figure 10 shows a fitting that has been squashed from using a vice or similar clamping device to hold the fitting to facilitate nozzle assembly. Anytime the outer cover is missing, the hose is kinked, crushed, twisted or the fitting is squashed oval the assembly must immediately be taken out of service. Refer to section 6.4 for more information on flex lance fittings.

4.6 Chemical Attack

UHP hoses use very tough materials that resist fatigue and abrasion, but can still suffer chemical attack. In water jetting applications, chlorine and fluorine are the two main chemicals of concern and are present in all city municipalities. If these chemicals are concentrated, then the core tube may experience crazing. Crazing is a condition where the core tube has longitudinal cracks in the core tube. Unfortunately at this time not enough data has been collected to know what concentration levels will chemically attack the tube or what circumstances allow chorine and fluorine to be present in these concentrations. Future tests will help understand this problem and offer guidelines to detect and control chemical attack.

5. PRACTICES THAT IMPROVE SERVICE LIFE

5.1 Hose Fitting Stress

Reduce stress at the fitting by using stiffeners or supporting the hose so it is straight for a minimum length of 3 times the hose OD. Install adapters that let the hose hang straight down as opposed to having the hose exit the pump or gun horizontally and then drooping down to the ground. If the hose is hanging from a great height, use support grips to support the weight of the hose rather than having the fitting support the weight. Do not torque or twist the hose assembly.

5.2 Pressure Spikes and Pulsations

Minimize pressure spikes and pressure pulsations as much as possible. Pressure spikes are internal to water jetting systems and cause internal damage to all working components of the system. Pressure spikes are often created when the gun or lance is pressured up. The release of pressure

(continued on page 11)

by the relief valve is not instantaneous so there is a moment when the pressure exceeds the relief set point and creates a pressure spike. Pressure spikes are often higher than the rated working pressure of the hose assembly and overly stresses the hose construction.

UHP hose typically contracts upwards of 2%. For each pressure pulsation, the hose contracts and elongates. Use accumulators or pressure pulsation dampeners, if available from the manufacturer, to smooth out the pressure wave. Operate the pump at the manufacturers recommended RPM. Operators must not decrease the pump speed (RPM) to lower the flow rate, as this will create severe pressure pulsations.

5.3 Flexing and Twisting

UHP hose is designed to bend and flex under high pressure. In one extreme application, the hose is oscillated side to side in a 60-degree arc at frequencies upwards of 60 cycles per minute. The hose performs very well; however, the extreme flexing causes the reinforcement to fatigue. Another hose application is found in boring machines. The hose is rotated to assist in the directional control of the hole being drilled. Please note that service life will be reduced if additional stresses such as flexing and torsion are subjected to the hose. Lab tests show that if a UHP hose is twisted 10 degrees, service life will be reduced. Refer to Table A for results of torsion tests.

55ksi Hose Impulse Test	Test Results
Torsion Test	10 % reduction of impulse life with 10-degree twist.
Bent Fitting Test	63 % reduction of impulse life when bent at minimum bend radius without keeping hose straight behind fitting.
Compressive/Tensile Test	52 % reduction of impulse life with 60 lb. continuous axial compressive or tensile load.

Table A

5.4 Abrasion

A primary source of hose failure is abrasion resulting from cuts, friction caused by the hose rubbing on the

(continued on page 12)