REMR TECHNICAL NOTE CS-ES-3.5

UNDERWATER CLEANING OF CONCRETE AND STEEL: HIGH-PRESSURE WATERJETS

PURPOSE: To provide information on high-pressure waterjets for removing fouling and corrosion from the submerged portions of concrete and steel structures.

APPLICATION: Diver-operated, high-pressure waterjet tools can be used to effectively clean underwater surfaces. Cleaning is often required to enable underwater inspections, maintenance, or repairs. Waterjet cleaning systems are currently used in the offshore oil industry and by the US Navy. There are two general types of high-pressure waterjet tools: larger high-flow devices and smaller low-flow tools. High-flow waterjets use more than 6 gpm and often require a retrojet to counterbalance the cleaning jet reaction force. Low-flow waterjets use 3 to 5 gpm and are small, lightweight pistol-like devices.

ADVANTAGES: Use of high-flow waterjets provides a fast and effective method for removing heavy fouling and corrosion from underwater structures. Use of low-flow waterjets provides a fast and effective means for removing light to moderate fouling and corrosion from submerged structures, particularly in limited-access areas. Water jetting is less time-consuming than conventional underwater cleaning methods such as scraping, chipping, and brushing. Cleaning rates of up to 8 sq ft/min can be obtained with high-flow waterjets and up to 6 sq ft/min with low-flow waterjets, depending upon the fouling amount, construction material, and operator experience.

LIMITATIONS: Handling of a high-pressure waterjet is a potentially dangerous operation. It is important that all personnel be aware of the operational hazards and receive proper training before underwater operation.

PERSONNEL REQUIREMENTS: A trained and qualified scuba diver is required to operate a high-pressure waterjet underwater. Another person is required to operate the controls and monitor the performance of the power source. A diving supervisor typically is required to monitor the diving operations and also to control a topside on/off foot valve for added safety.

EQUIPMENT DESCRIPTION: There are several commercially available high-pressure underwater cleaning systems. Components required in these systems include the pump/power source, the waterjet tool, and the interconnecting hardware such as high-pressure hoses and connectors.

Two types of diver-operated, high-pressure, high-flow cleaning systems are available: those that are counterthrusted and those that are not. One counterthrusted system (Figure 1) operates at 4,000 to 10,000 psi with a 14- to 26-gpm flow rate. The waterjet gun is reactionless; i.e., it diverts 50 percent of the flow through a retrojet nozzle for thrust compensation. The retrojet is shrouded with a diffuser for safety purposes. The diffuser is

simply a hollow tube with holes in it that surrounds the retrojet and reduces the penetrating effect of the waterjet for diver protection. Interchangeable fan and straight jet nozzles are available. Fan jet nozzles clean a wider path, whereas straight jet nozzles have a greater cleaning intensity.

Another reactionless high-flow (18- to 22-gpm) waterjet cleaning system operates at lower pressures (3,000 psi). This system has an adjustable retrojet that enables the diver to vary the retrojet flow and control the amount of thrust into or away from the work surface.

The second type of high-flow cleaning system (Figure 2) operates at 4,000 to 10,000 psi and 7 to 10 gpm. Only half the flow is required, since this tool does not use a retrojet for thrust compensation. A shoulder stock is usually provided on the tool to help support the diver against the backthrust.

Diver-operated, high-pressure, low-flow cleaning systems operate at approximately 10,000 psi with a 3-gpm flow rate. The waterjet pistol (Figure 3) is small and lightweight, weighing about 5 lb (in the dry). The pistol can easily be operated with one hand and has a 5- to 10-lb reaction force depending upon the type of nozzle used. Interchangeable fan and straight jet nozzles are available. Longer barrels can be used to reach into crowded, otherwise inaccessible, areas. Also, a shoulder stock can be used to help support the diver against the back-thrust if needed.

The waterjet tools may have a dump valve to exhaust the flow at a low and harmless pressure whenever the trigger is released. If the tool does not have a dump valve (that is, it uses a direct shutoff valve), then a means for recirculating the flow at the power source is required. Tests conducted by the Navy (Ref a) indicated that divers prefer using a tool with a pilot-operated, direct shutoff valve. The waterjet pistol includes an on/off safety lock and a trigger guard to prevent inadvertent operation of the tool.

A reactionless high-flow waterjet with variable flow rates and pressures is recommended for cleaning heavily fouled concrete and steel structures. Lower flow rates and pressures should be used to clean underwater timber structures to avoid damaging the timber itself.

Manufacturers of high-pressure, high-flow waterjet cleaning systems include Jetin-Sullair, Inc., and Butterworth Systems, Inc. The low-pressure, high-flow device is manufactured by Seaco, Inc.

Manufacturers of high-pressure, low-flow waterjet cleaning systems include Flow Industries, Inc., and Daedalean Associates, Inc. The Flow Industries, Inc., system can operate both waterjet devices and hydraulic-powered hand tools. The Flow Industries, Inc., system can also operate on seawater, eliminating the requirement for a freshwater supply in marine applications.

COSTS: The cost of a complete high-pressure waterjet cleaning system, including the pump/power source, high-pressure hoses, and waterjet tool, ranges from approximately $25,000 to $50,000, depending upon the size and type of power source required. The waterjet tool alone ranges from approximately $750 to $2,000.

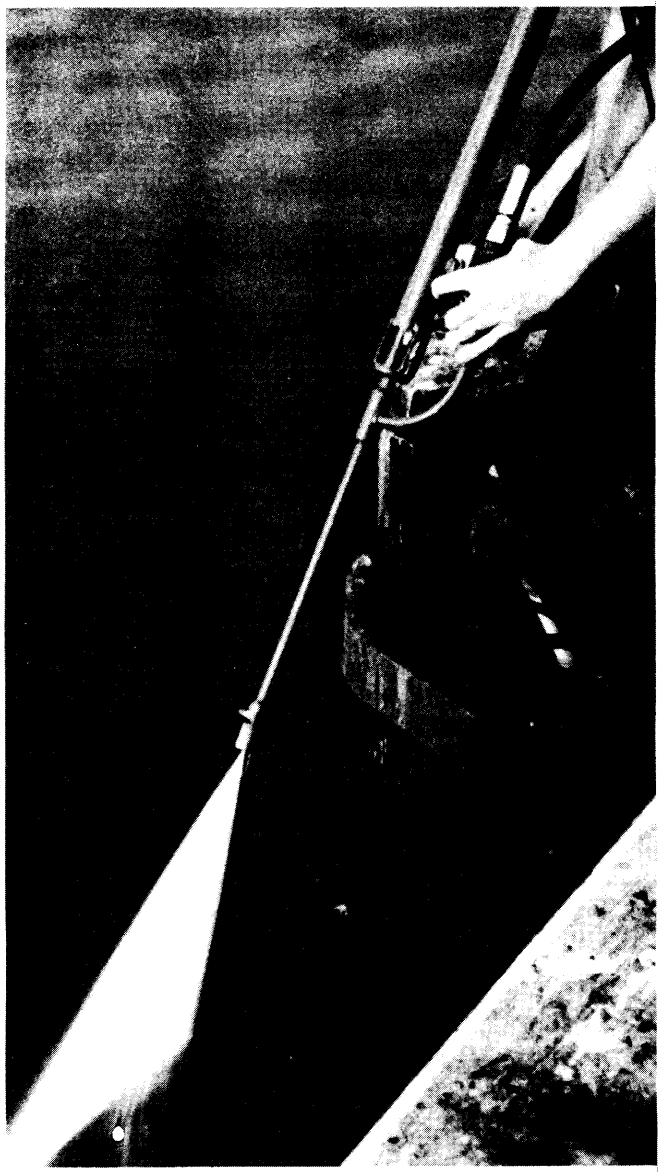

Figure 1. High-pressure, high-flow reactionless waterjet.

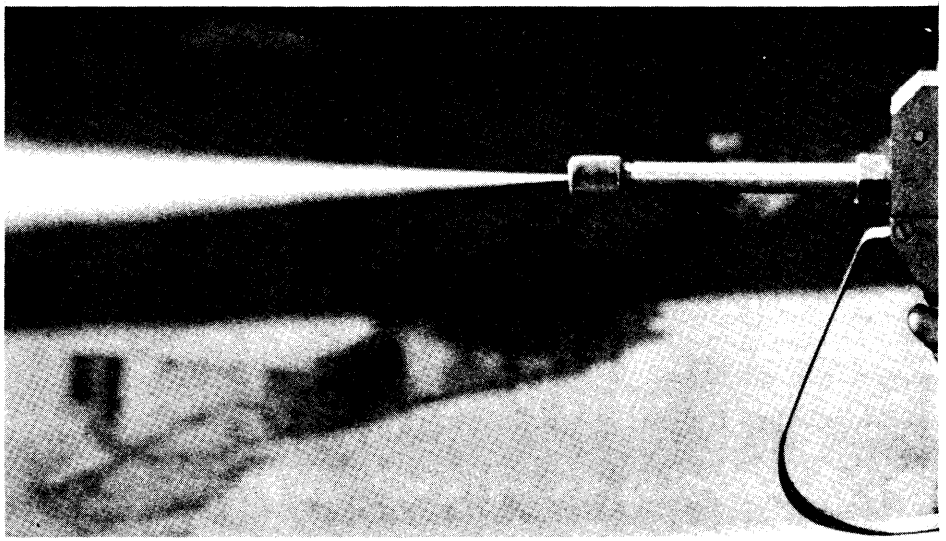

Figure 2. High-pressure, high-flow waterjet tool with shoulder stock.

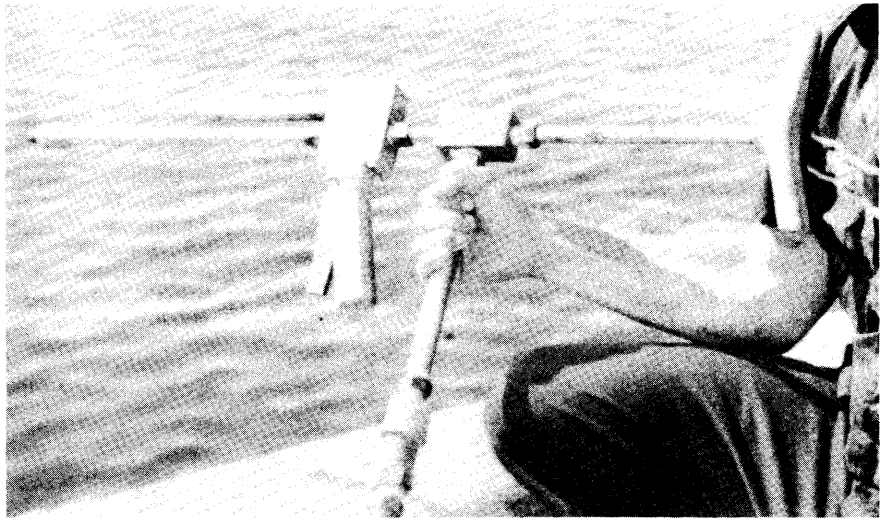

Figure 3. High-pressure, low-flow waterjet pistol.

MANUFACTURERS: Jetin-Sullair, Inc.
5131 NE Union Avenue
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Tel 503-249-8191

Seaco, Inc.
Cavico Division
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Butterworth Systems, Inc.
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Tel 201-765-1546

Flow Industries, Inc.
21414 68th Ave South
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Daedalean Associates, Inc.
Springlake Research Center
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ENVIRONMENTAL CONSIDERATIONS: Cleaning operations with the equipment discussed in this Technical Note may increase the level of suspended and soluble materials in the water column adjacent to and downstream from the operation. Whether these increases will result in unacceptable water quality or other undesirable environmental consequences should be evaluated on a project-specific basis. Variables that influence the nature and magnitude of any impacts include, but may not be limited to: the hydrodynamic setting, the physical and chemical characteristics of the sediment or residue generated during the cleaning or dredging process, and the regulatory environment. Personnel familiar with evaluating water quality impacts of construction operations should be consulted during the early stages of project planning to ensure that appropriate water quality criteria and other environmental regulations will be met.

REFERENCES:

a. Underwater surface cleaning of waterfront structures. C. A. Keeney. Naval Civil Engineering Laboratory, Port Hueneme, CA, Feb. 1981. TN-1602.

b. Procedures and devices for underwater cleaning of civil works structures. C. A. Keeney, Naval Civil Engineering Laboratory, Port Hueneme, CA. Prepared for US Army Engineer Waterways Experiment Station, Vicksburg, MS. Technical Report REMR-CS-8 (in preparation).