Western Dredging Association (WEDA) Environmental Excellence Award Application

US Army Corps of Engineers
Dredge MURDEN
Water Hydraulics System

USACE Marine Design Center (CEMDC)

USACE District Wilmington NC (CESAW)

BOC Water Hydraulics, Inc.

Conrad Industries, Inc.

14 June 2013

Section 1: SUMMARY

The Dredge MURDEN is a 500 cubic-yard shallow draft trailing suction split-hull hopper dredge. Hopper dredges are self-propelled ships used to dredge entrance channels, ocean bars, or rivers with moderate to high marine vessel traffic where maneuverability and/or seakeeping is necessary to not impede navigation/commerce. Hopper dredges can continue to work in fairly heavy weather and in rougher sea states than any other type of dredge. Dredged material is moved out of the channel using centrifugal pumps, either inboard (in pumproom) or submersible (mounted on the dragarms), and eroded/excavated by the dragheads, which are towed along the channel bottom at the end of the dragarms. A typical dredging operation will fill and empty the hopper several times a day. The hopper is an integral part of the MURDEN's hull structure. To empty the hopper, the MURDEN splits in half and the dredged material is flushed out through the opening in the bottom of the ship. Once the hopper is flushed, the hopper closes and the MURDEN is ready to return to its dredging operations.

Water hydraulics provided the United States Army Corps of Engineers (USACE) with an elegant and simple solution to a very serious potential problem – contamination from hydraulic oil leaks from the hopper hydraulic system could potentially pollute waterways during dredging operations. In order to eliminate any potential adverse environmental effects from oil hydraulic system leakage, BOC Water Hydraulics Inc. designed and built a complete water hydraulic system to open and shut the hopper on a new innovative split-hull hopper dredge.

- Goal: Provide significant improvement in environmental considerations associated with using water hydraulic components for the design and installation of a new split-hull dredge hopper operating system that have traditionally been mineral-based oil hydraulic systems.
- Objectives:
    - Provide an integrated design into the dredge's structure, mechanical, and electrical systems.
    - Provide a maintainable system, including submerged rams.
    - Provide readily available parts support.
- Accomplishments:
    - First marine application
    - First dredging application
    - Proved a viable underwater marine system
- Award Category: Navigation Dredging

Section 2: PROJECT TEAM DESCRIPTION

A complete list of project team members and their affiliations, including the project owner, the role of the team members, WEDA membership status, and the nominating entity is provided below:

Robert Sattin, USACE Wilmington District, Chief of Operations, Project Owner
Greg Frith, USACE Wilmington District, Port Engineer
Lawrence Calame, USACE Wilmington District, Port Captain
David Cribbs, USACE Wilmington District, Dredge MURDEN Chief Engineer
John Crabtree, USACE Wilmington District, Dredge MURDEN Engineer
Gregory Lee, USACE Marine Design Center, Chief Naval Architect
Vinton Bossert, USACE Marine Design Center, Sr. Marine Engineer, WEDA Member/Nominating Entity
Matthew Newborn, USACE Marine Design Center, Project Engineer
Allen Epps, USACE Marine Design Center, Project Manager

Joe Cieslak, USACE Marine Design Center, Construction Technician
Todd Olson, BOC Water Hydraulics Inc., President, WEDA Member
Robert Guy, BOC Water Hydraulics Inc., Field Service/Commissioning, WEDA Member
John Fisher, BOC Water Hydraulics Inc., System Design, WEDA Member
Neil Verret, Conrad Industries, Inc., Project Manager
AJ Blanchard, Conrad Industries, Inc., Contracts Administrator
Kirt Hernandez, Conrad Industries, Inc., Project Manager
William Jordan, Bristol Harbor Group, Senior Naval Architect
Pete DeJong, Digital Automation and Control Systems (DACS), President
Johan Sperling, Jensen Maritime Consultants Inc., Vice President

Section 3: ENVIRONMENTAL BENEFITS

The water hydraulics system fulfills all operational work requirements while eliminating hazards to the surrounding environment. It eliminates any potential adverse environmental effects from oil hydraulic system leakage.

All operators understand that absolutely NO hydraulic system is 100% leak free. Every hydraulic system leaks to some degree. No matter whether the system is new, recently refurbished, or a long-standing reliable system, dealing with hydraulic leaks is a fact of life. Fittings wear, hoses break, o-rings get cut and components unpredictably fail. The most aggressive preventive maintenance program can never fully guarantee that fluid will not leak from a hydraulic system. To complicate matters in the dredging industry, many of these critical hydraulic systems operate near or sometimes even in (as is the case here with hopper-hull hydraulics) the open water itself. But reality is that hydraulic systems provide unique high force solutions for daily tasks in compact packages. Hydraulic systems are a 'must' in any dredging application.

Instead of attempting to eliminate the likelihood of an unanticipated hydraulic leak or worse, uncontrolled hydraulic oil spill to the environment, the USACE envisioned a different solution, one that did not completely eliminate the likelihood of leakage. Rather, the USACE saw value in eliminating the possibility of contamination from the fluid media. Using water as the hydraulic media to support operations rather than oil based fluids outright eliminates the possibility of environmental contamination. In the USACE operating model, hydraulic problems continue to pose challenges and issues for operation of the dredging vessel, but concerns of damage or issues beyond the hull are gone! Bottom line, Owners, Operators, Captains and crews can rest easy knowing that an unanticipated hydraulic failure is not going to result in damage to the surrounding environment.

Section 4: INNOVATION

- First marine application
- First dredging application
- Proved as a viable underwater marine system

In business, being a first mover often comes with significant risk. If one moves too quickly to adopt new technology that is not ready for prime time, then one risks stranding precious economical capital and hurting ones reputation. Only a small number of market leaders and trend setters will move into uncharted territory because they believe that they are doing the right thing and heading in a direction that the industry must go. In selecting water hydraulics for such a vital ship system, USACE went beyond small incremental steps forward and took a big leap in a new direction. Embracing water hydraulics technology for its hopper/hull control system was a huge business risk with a potential real environment

payoff. Results now show that the Marine Design Center was visionary in seeing the potential of water hydraulics applied to dredging operations. Greg Lee, MDC's Chief Naval Architect, was the driving force in moving the idea of water hydraulics into the MURDEN's Concept Design, which was developed by Jensen Maritime Consultants, Inc.

To date, none have attempted to go this far in applying water hydraulics to a dredge application. Water hydraulics is proven technology, used in numerous applications throughout industry. The true innovation in this project consisted of marrying proven component level technologies and control system capabilities to meet the needs of the dredging hopper application. For this project to be successful, the USACE had to choose the right partners with the right skill sets to turn concept to reality. BOC Water Hydraulics Inc. and Conrad Industries brought such skills to the project, including Bristol Harbor Group and DACS.

Traditional design methods and standards were used in developing this application. The hydraulic system met the design standards of ABS Rules for Building and Classing Steel Vessels.

The USACE is a steward for some of the Nation's most valuable natural resources, and this application provides a sustainable solution that addresses short and long-term environmental, social, and economic considerations for the Corps Wilmington, NC District and many of the shallow draft ports along the East and Gulf coasts. The Corps is obligated to seek balance and synergy between natural systems and human development activities when it comes to its missions, facilities and operations. The Corps also seeks to ensure that its activities do not negatively impact the resource needs of future generations. The MURDEN's water hydraulic system fits the Army's "triple-bottom-line-plus" of sustainability – mission, environment, community and economic benefit.

Section 5: ECONOMIC BENEFITS

The efficiency of a hopper dredge is the relationship between the cost and the production (material removed from the channel). The dredging efficiency is measured in $/cubic yard and is a function of the cost of the entire dredging cycle including excavation/ hopper loading, propelling to unloading site, unloading, propelling back to dredging site, and the other operational costs of the dredge (crew, fuel, waste disposal, etc..).

A water hydraulic system will cost more initially due to materials, however life cycle costs will be less due to avoiding any costs for hydraulic oil spill mitigation, cleanup, fines from state or federal agencies due to spilled oil, intangible costs such as bad public relations caused by a catastrophic event, and other environmental-related costs (toxicity, biodegradability, sheen, etc…). In addition, costs for purchase, transport, handling, and storing hydraulic oil over the life of the dredge will be completely eliminated, as well as the risk of a fire associated with hydraulic oil.

This project opens the door to other dredging companies to evaluate the feasibility of water hydraulics in their respective dredging operations. A market based, successful proof of concept such as the MURDEN creates the opportunity for more innovation in terms of technology enhancement application. Furthermore, innovative operators can develop new value to their marketing and value added to their business proposition. Imagine the market advantage to one operator who can guarantee zero likelihood of contamination competing against those who are offering traditional based solutions. The potential benefits to the economy are positive by all measures.

Section 6: TRANSFERABILITY

Technology is proven, reliable, and transferable to any new or major hopper dredge mid-life retrofit. The technology is transferable to all split-hull and standard mono-hull hopper dredges. All hopper dredges

include significant fluid power (hydraulic) systems over the hopper, which is open to the sea. There are also many deck mounted hydraulic systems employed on hopper dredges, cutter dredges, and excavating dredges which may benefit from this technology. Oil leaks from deck mounted systems are less likely to enter the watershed, but when oil leaks on deck followed by heavy rains, some fluid eventually finds its way into the natural resource.

The capabilities of water hydraulics are equal to those of oil hydraulics. Water hydraulic components can provide a full range of operating pressures, flows, and capabilities to meet a complete range of hydraulic demand in dredging applications. Pumps, valves, cylinders and support components are readily available for use in developing commercial duty systems today.

Section 7: OUTREACH AND EDUCATION

Given the relative infancy of this project, outreach and education has been limited to conference presentations and trade journal publications. To date, papers detailing this project have been presented at 2012 Dutch Fluid Power Conference in Amsterdam, Netherlands in September 2012 and will be presented at WEDA 2013 in August 2013.

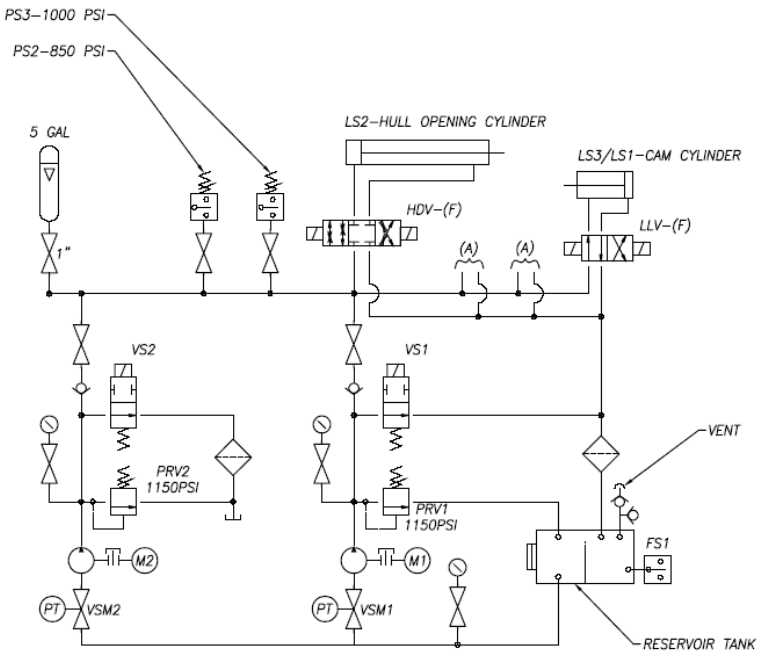
The trade industry press has also been helpful in educating industry with respect to this project. WorkBoat featured the MURDEN on its cover in its July 2012 issue. In the cover story, WorkBoat noted that "The Corps wanted the Murden to be environmentally friendly to the areas in which it will work. Bill Gretzmacher, director of the Marine Design Center, said that's what led to the agency's use of water hydraulics instead of oil." (July 2012 issue, P 42). Furthermore, the Murden was featured as one of five ships considered for the Ship of the Year award in American Ship Review 2013. In its article on the Murden, Brian Gauvin captured the excitement of the Corps with respect to embracing water hydraulics "This is where it all happens,' said [Matt] Newborn. 'The water hydraulic system is used for opening the hopper latch and the hopper splitting cylinder. It's self-contained and self–maintaining and is rugged and durable. The system operates on water, at 1200 psi and uses non-toxic anti-freeze. So issues associated with hydraulic oil leaking from the hull rams are eliminated." (American Ship Review, 2013, p 38).

Section 8: OTHER

Forging a new direction and taking big risks for the sake of improving the environment is a rare occurrence, particularly when such a step involves spending additional precious investment dollars beyond typical levels. The MURDEN's team deserves to win this coveted award because it has accomplished such a monumental task.

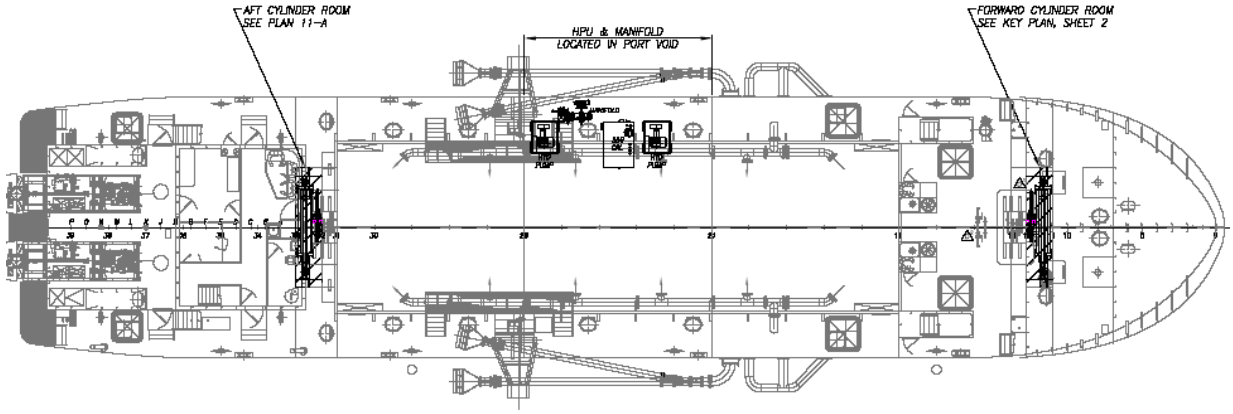
Section 9: SYSTEM OPERATION

The hopper/hull hydraulic system is designed and constructed to operate on straight water. The hopper hydraulic system consists of the following key components as shown in Figure below.



Simplified Hopper Hydraulic Schematic

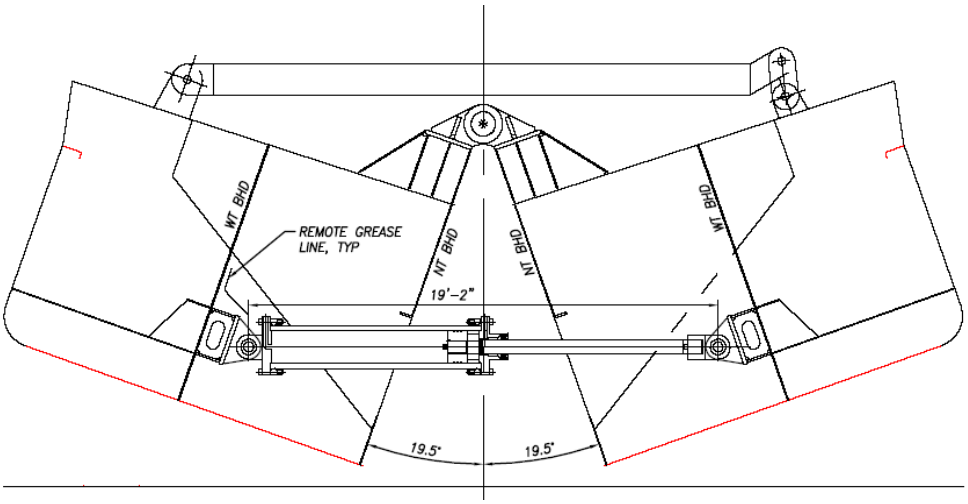
The system consists of one (1) hydraulic power unit with two (2) pump/motor sets (one operating; one pre-piped standby unit), two (2) double acting cylinders to open/close the hull, two (2) double acting cylinders to engage/disengage the latching mechanism and all necessary control valves to safely and effectively operate the system. The system is designed to open/close the hull with one (1) cylinder only. Normally, however, the hull will be operated using both hull cylinders operating together.
Locations of these key components aboard the dredge are shown in Figure 2.



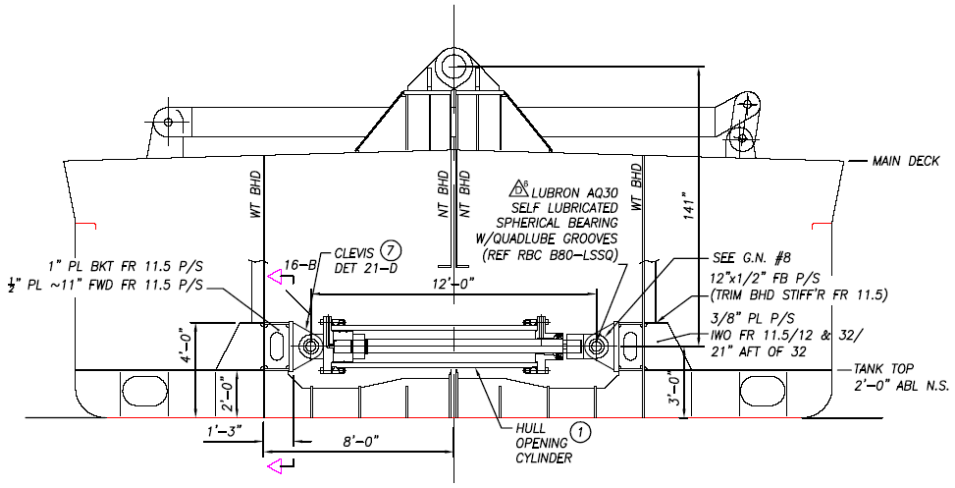
Installation of Key Components on Dredge MURDEN

Background of operation – The two hull cylinders are sized at 406 mm (16 in) bore, 178 mm (7 in) diameter rod with a 2184 mm (86 in) stroke. While in retention, the hopper load of 320 metric tons creates 150 bar (2175 psi) rod end pressure per cylinder or 300 bar (4350 psi) during a single cylinder operation. Cylinders are designed for a working pressure of 320 bar. Although the rams are capable of 7 feet of stroke, it only requires a partial opening to empty the hopper.

Hull cylinders are installed below water level may be subjected to brackish or salt water. Several design enhancements are incorporated into the cylinders to ensure that they can withstand the harsh elements of being in a continuous submerged condition. Cylinders are coated with marine grade epoxy and the piston rod is constructed from a high grade marine rated stainless steel.



Hopper Cylinder Extended, Hopper Open



Hopper Cylinder Retracted, Hopper Closed

Hopper Full of Sand (Clearwater, FL)

Hopper Empty and Open