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ABSTRACT

RECENT TECHNOLOGICAL DEVELOPMENTS IN THE DESIGN OF SEAGOING HOPPER DREDGES

by

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Most dredging in approach channels to the coastal ports of the United States is performed by seagoing trailing suction hopper dredges. In the past, this type of dredge was owned and operated exclusively by the U. S. Army Corps of Engineers (Corps). However, with recent legislative actions and related changes in Corps policies, a significant amount of the Federal hopper dredging annual workload is being done with industry dredges under contract.

In the future, the Corps will operate and maintain only a minimum number of hopper dredges based principally upon national defense and emergency requirements. Three new hopper dredges were recently constructed to serve as the nucleus of this minimum Federal fleet. Their principal physical characteristics and design features are described along with the factors that dictated or significantly affected the designs.

Public Law 95-269 requires that the minimum Federal fleet have the capability to respond immediately to all national defense and emergency needs in the United States and overseas. Therefore, these vessels must include a variety of capabilities to provide for a wide range of operational conditions.

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RECENT TECHNOLOGICAL DEVELOPMENTS IN THE DESIGN OF SEAGOING HOPPER DREDGES

INTRODUCTION

In general, the preponderance of dredging in approach channels to coastal ports around the world is performed by seagoing hopper dredges. Until recently, such dredges employed in the construction and maintenance of navigation channels in the United States were owned and operated exclusively by the U. S. Army Corps of Engineers. Over the past five years, as a result of legislative actions (notably Public Law 95-269) and the development of new Corps policies relating to contractual procedures and the conduct of hopper dredge work under its jurisdiction, eleven privately-owned hopper dredges have been constructed. Consequently, a significant amount of the Federal hopper dredging workload is now being performed under contract.

The Corps of Engineers will continue to own and operate four hopper dredges (referred to as the "minimum fleet" in Public Law 95-269). Public Law 95-269 also indicates that the "minimum fleet" will be kept fully operational and be technologically modern in order to respond immediately to national and international energy and defense requirements. With this objective in mind, the Corps recently constructed three new hopper dredges: a large, a medium and a small class. These dredges comprise the nucleus of the Corps of Engineers' technologically modern minimum fleet needed to respond immediately and effectively to national defense and emergency situations.

The purpose of this paper is to describe the principal characteristics and design features of the three new Corps of Engineers hopper dredges and to discuss various operational requirements and conditions that led to their determination. A discussion of the minimum dredge fleet concept and related factors as well as pertinent Corps design policies are also included.

BACKGROUND

As a result of the National Dredging Study (1974), the Corps of Engineers initiated a nation-wide competitive bidding program to determine the capability of the dredging industry to perform a larger portion of the annual maintenance dredging workload. This program, designated as the Industry Capability Program (ICP), provided an opportunity for the dredging industry to bid on a large percentage of the work which had been historically accomplished with Corps dredges. As such, the program was an incentive which led to the construction of seagoing hopper dredges by private industry. Presently there are eleven such dredges available for trailing suction dredging operations and another is under construction by the industry.

Public Law 95-269 enacted on 28 April 1978, requires that the Federal dredging workload be accomplished in the most economical or advantageous manner by the use of either Corps or industry plant. In addition, this legislation indicates that a study be undertaken by the Corps of Engineers to determine the minimum Federally-owned dredge fleet required to perform emergency and national defense work. The legislation also requires that a "minimum fleet" of technologically modern dredging plant shall be retained by the Corps in a fully operational status ready to respond to emergency and defense assignments on a global basis. A study of the seagoing hopper dredge minimum fleet needs was recently completed. After reviewing the study, the Assistant Secretary of the Army for Civil Works and the Office of Management and Budget determined that four Corps hopper dredges could meet the military and emergency dredging needs of the nation, although not both on a simultaneous basis. The determination that a minimum fleet of four hopper dredges would be suitable to provide for emergency and defense needs was based largely on the fact that the Corps of Engineers would establish a contractural arrangement with industry dredging companies for a reserve fleet of industry dredges to augment the Corps minimum fleet. The reserve fleet program, which we place into affect soon, will be similar to the reserve equipment programs used by the Air Force and the Navy.

In developing the hopper dredge minimum fleet requirements, paramount consideration was given to meeting the national defense and other emergency needs pursuant to Public Law 95-269. The major factors considered were as follows:

- Geographical distribution of navigation projects in the United States and various deployment areas overseas related to national defense.

- Project dimensions and operational conditions as related to the sizes and types of hopper dredges required.

- The frequency of dredging cycles required at each project, i. e. annual, bi-annual or multi-year cycles.

- The level of maintenance required on each project.

- Projects which have an unusually rapid and extreme shoaling rate and require an immediate response capability in order to maintain or restore normal navigation.

- Haul distances from navigation projects to acceptable disposal areas. (Note: During the past ten years or so there has been a general tendency for an increase in these distances which has resulted in a need for longer dredging assignments).

- Diverse types of material generally encountered at various projects, which range from light fine-grained silts to heavy sand and gravel.

- Requirements for direct pump-out operations which have become more prevalent in the past ten years or so, because of environmental considerations, including the need for making beneficial use of the dredged material such as for beach nourishment and hurricane protection.

- Restrictions on pumping beyond overflow during hopper loading operations in certain projects.

- Dredge operating schedules.

- The transit time required to move from one location to another. (Note: The distances range up to 1,000 miles in the coastal regions and in the Great Lakes).

The construction of three new hopper dredges constitutes the first step towards the attainment of a technologically modern minimum fleet of hopper dredges to serve the purposes outlined above. These new dredges were designed for multi-purpose use, with the capability of working on a wide variety of projects, rather than any particular project or type of project. Consequently, various features have been incorporated in these dredges that otherwise might not be justified if assignment on only a single or few projects were contemplated.

GENERAL DESIGN POLICY, PHILOSOPHY AND PROCESS

The seagoing hopper dredge, which was invented by the Corps of Engineers many years ago, is one of the most versatile dredging tools available. It represents well over a century of development in design and

operational experience. Corps of Engineers dredges are designed and constructed for long-term use over a normal lifespan of about thirty years. As a matter of general policy, all Corps floating plant is designed, constructed, operated and maintained in accordance with the rules and regulations of the U. S. Coast Guard and other regulatory bodies.

As indicated in the foregoing background discussion, in designing its hopper dredges, the Corps of Engineers must take into consideration a wide variety of factors to ensure suitability for multi-purpose use in the fulfillment of its overall civil and military mission. This basic philosophy and the need for providing a maximum degree of mobility, operational versatility and self-sufficiency, especially when operating in relatively remote locations, results in the adoption of various compromises when establishing principal features and major design criteria for new dredge designs. In addition, in order to spearhead and stimulate the development and general use of dredge improvements in the United States, the Corps continues to take the view that its minimum hopper dredge fleet should be equipped with the latest type of machinery and equipment available. Therefore, on our three new seagoing hopper dredges, we have included innovative systems of promise that may require further development, test and evaluation under actual job conditions. By maintaining this initiative in the hopper dredging field, we feel that meaningful contributions to dredge technology and the state-of-the-art can be achieved.

The design of Corps hopper dredges involves considerable study and planning efforts on the part of our design and operational staff as well as the Corps of Engineers Marine Engineering Board. The Marine Engineering Board is comprised of civilian staff engineers from the various regions of the United States with expert knowledge in dredge and other floating plant operations and requirements. This Board is responsible to the Director of Civil Works for recommending principal features and design criteria for new dredge construction, as well as for other major items of marine plant. Design work, from conceptual to preliminary, to contract plans and specifications, is assigned to the Marine Design Center in Philadelphia, Pennsylvania, which is under the staff supervision of the Dredging Division of the Water Resources Support Center located at Fort Belvoir, Virginia.

NEW CORPS OF ENGINEERS HOPPER DREDGES

The three new hopper dredges currently in operation are:

- The WHEELER, a large class hopper dredge (LCHD) constructed by Avondale Shipyards, Inc., New Orleans, Louisiana.

- The ESSAYONS, a medium class hopper dredge (MCHD) constructed by Bath Iron Works, Bath, Maine under sub-contract with Sun Shipbuilding and Dry Dock Co., Inc., Chester, Pennsylvania.

- The YAQUINA, a small class hopper dredge (SCHD) constructed by Norfolk Shipbuilding and Dry Dock Corporation, Norfolk, Virginia.

GENERAL DESCRIPTION

All of our new dredges are equipped with side dragarms, port and starboard, and in the case of the WHEELER, an additional dragarm is provided which is arranged in a centerwell installed longitudinally through the hopper section. The principal components are located in conventional hopper dredge sequence, with the pumping machinery forward, hopper section amidships and the propulsion and generating machinery aft. In accordance with our long term design practice, the vessels are equipped with twin screws and rudders, and the propulsion system consists of diesel engines driving controllable pitch propellers through reduction gearing.

The vessels were constructed in accordance with applicable rules and regulations of the U. S. Coast Guard and are certificated for "Oceans" service in the case of the two larger dredges and for "Coastwise" service in the case of the YAQUINA. All three vessels were inspected, surveyed and classed by the American Bureau of Shipping (ABS) for the Maltese Cross A1 dredging service, including certificate of classification Maltese Cross ACCU for unattended operation of machinery.

The principal dimensions and general design characteristics of the dredges are given in Table 1. Various features are described and discussed, particularly from the design decision viewpoint.

Hull Size and Hopper Capacity

Many of the navigation channel projects in the coastal regions of the United States that are constructed and maintained with trailing suction hopper dredges have dimensions (depths and widths) that vary over a wide range. Present project depths (usually below mean low water datum) range from 12 feet (3.66 meters) to 50 feet (15.24 meters) with channel widths varying from as narrow as 200 feet (60.96 meters) to over 2,000 feet (609.60 meters). Obviously, dredges of various sizes and hopper capacities are needed because of these variances. Consequently, the Corps of Engineers hopper dredge fleet, both existing and as projected for the future under the minimum fleet concept, is comprised of vessels in three distinct categories based on hopper capacity:

- o Small Class Hopper Dredge (SCHD) - Hopper capacity of 1,500 cubic yards (764.6 cubic meters) or less.

- o Medium Class Hopper Dredge (MCHD) - Hopper capacity of over 1,500 cubic yards (764.6 cubic meters) up to 6,000 cubic yards (4,587.6 cubic meters).

- o Large Class Hopper Dredge (LCHD) - Hopper capacity of over 8,000 cubic yards (6,116.4 cubic meters).

While all three of the new Corps hopper dredges are multi-purpose dredges, there were a number of specific requirements that dictated or significantly affected their design dimensions. In the case of the YAQUINA (SCHD), job conditions in various shallow draft projects on the west coast of the United States, which is the assigned area of operation of this dredge,

dictated a vessel length of not more than 200 feet (60.96 meters). Other operational requirements indicated that the dredge should be capable of carrying a load of at least 300 cubic yards (229.38 cubic meters) of sand at a reduced loaded draft of not more than 10 feet (3.05 meters) with 100 percent consumables (fuel, water, etc.) aboard. These requirements resulted in the selection of a vessel beam of 58 feet (17.68 meters) and a hull with a beam/length ratio of slightly under 3. Model testing performed for the Corps for comparable designs in the past indicate that ships in a similar size range with beam/length ratios greater than 3 are inclined to have poor directional stability characteristics.

In developing the design criteria for the ESSAYONS, the hull length of 350 feet (106.68 meters) and design draft loaded of 27 feet (8.23 meters) were selected as limiting dimensions based upon an analysis of operational conditions in the various projects around the country on which existing Corps dredges in the medium class category are employed.

For the WHEELER, a hull length of roughly 400 feet (121.92 meters) and a design draft loaded of less than 30 feet (9.14 meters) were the original design objectives. However, an increase in length from 400 feet to 409 feet (124.66 meters) in the final stages of the contract design was necessitated by revisions to the general arrangement in order to satisfy damage stability requirements.

With respect to hopper capacity, it is our design practice to provide the largest volumetric hopper space that can be physically accommodated within hull size limitations and other constraints such as intact and damage stability requirements. The average in-place density of bottom materials (exclusive of rock) removed in the maintenance dredging of coastal navigation projects is in the range of specific gravity 1.4 to 1.6. Therefore, hopper dredges designed for general purpose use should have a hopper volume sufficient to permit essentially full loads of materials in that density range to be dredged and transported at the loaded design draft. As indicated in Table 1, the volumetric hopper capacities of all three new Corps hopper dredges were designed based on loading materials with specific gravity ranging from 1.8 to 2.0 to provide optimum load carrying capabilities.

Damage Stability

The area and mode of operation of hopper dredges subject them to a substantial risk of accidents. As a result of a significant number of casualties experienced by our dredges over the years, the Corps of Engineers has long recognized the need to ensure that dredge hulls be designed to survive damage from collisions and groundings. The Corps of Engineers has followed a policy that all seagoing hopper dredges be designed to survive flooding of any two adjacent hull compartments, wherever practicable, and that in some cases (such as on smaller vessels) no less than a one-compartment standard of subdivision would be provided. In implementing this policy, the U. S. Coast Guard rules contained in its "Rules and Regulations for Passenger Vessels," Part 73, Watertight Subdivision and part 74, Stability, were followed.

As previously indicated, eleven privately-owned hopper dredges have been built in recent years and another is under construction. With the entry of private dredging contractors in the hopper dredging field, the Coast Guard has been studying the matter of damage stability of hopper dredges with the view towards imposing pertinent specific requirements. Proposed rules were published in the Federal Register, Vol. 44, No. 238 dated December 10, 1979 that "amend load line and stability regulations to permit deeper loading of hopper dredges on coastwise voyages than is presently permitted under the load line regulations and to require increased protection against flooding or capsizing of hopper dredges certificated by the Coast Guard". These proposed rules would require seagoing self-propelled hopper dredges to be designed to survive both side and bottom damage with the hoppers full. Dumping of the hopper load is not permitted and the maximum angle of heel permitted after damage would be 30 degrees, or any lesser angle where down flooding occurs. The rules, as presently proposed, are considered to be unduly restrictive particularly with respect to not permitting the hopper load to be dumped under any circumstance and requiring high density materials in the hopper to be treated as liquids.

House and Superstructure

As indicated by the outboard profiles of the three dredges (Figures 1, 3 and 5), the superstructure, including the pilot house, are located aft of the hoppers. This represents a significant departure from the Corps' past practice of locating the pilot house and certain accommodations in a forward superstructure as well as a superstructure aft of the hoppers. With the substantial reduction in operating crews permitted by modern marine power plants and dredging machinery provided with automated control systems, it is now possible to satisfy entire crew accommodation needs in a single superstructure aft while still keeping the aft trim of the dredge in light condition within tolerable limits. This arrangement also facilitates the centralization of all dredging system controls in the pilot house area so that a single Dredge Control Officer (DCO) on the bridge can operate the entire dredging system.

The superstructure decks and deckhouses on the two larger dredges are of conventional steel construction conforming in general to current marine practice. However, in the case of the YAQUINA, it was necessary to select a welded aluminum structure of reduced weight in order to help meet stringent operational draft and load-carrying requirements.

Habitability

The Corps of Engineers recognizes the need for providing suitable accommodations and habitable surroundings for operating personnel aboard its marine plant. Our new hopper dredges with sophisticated machinery and equipment demand highly qualified personnel who deserve comfortable living conditions, including provisions for recreation and entertainment facilities. However, space constraints on hopper dredges generally do not permit us to furnish the entire crew complement with single rooms and individual private sanitary facilities. The accommodation standard adopted for the three new dredges had to be restricted to providing single rooms with private

toilet and shower facilities for all personnel in officer categories and providing rooms occupied by no more than two persons with shared facilities for personnel in unlicensed categories. Recreation rooms for both officers and crew that provide facilities for reading, card playing, TV viewing, etc. are included on all three dredges. In addition, the ESSAYONS is equipped with separate card and game rooms and a small gymnasium.

Aside from space considerations, the environment of the living and working areas aboard the dredges is very important. For example, all staterooms, mess rooms, pilot house, dredging control station, engineer's central control room and public spaces (e.g. recreation rooms, hospital, etc.) are air conditioned. In addition, elevators are provided on the two larger dredges for ease of reaching difficult deck levels on board. Fluorescent lighting fixtures are used wherever practical and permitted by applicable rules to ensure better lighting, and extensive measures have been taken to minimize noise and vibration throughout the ships. Noise and vibration problems on diesel-powered hopper dredges have long been recognized, particularly since the adoption of modern light weight compact engines with relatively high rotative speeds. In recent years, we have successfully improved the habitability aboard our existing diesel-powered hopper dredges by providing enclosures around engines and other noise generating machinery. We also install vibration isolators on our major machinery and provide the most effective acoustic insulation possible on bulkheads and decks as well as other specific measures to attenuate noise and to avoid excessive vibration.

The contract specifications for the three new dredges included the following specific noise and vibration control requirements:

- Insulated enclosure over and around engineer's central control station, including acoustical sealing of all penetrations.

- Stiff engine foundations and suitable resilient mountings.

- Efficient sound attenuation devices for engine intake and exhaust systems.

- Flexible noise and vibration attenuating connections between engines, piping and ductwork.

- Extra stiff ductwork to prevent vibration with round ducts used where feasible.

- Selection of pumps, compressors and blowers with less objectionable noise characteristics where practicable.

- Lining of bulkheads and decks in machinery spaces with suitable acoustic insulation.

Propulsion Systems

Our design policy provides for the use of diesel engines driving controllable pitch (CP) propellers for hopper dredge propulsion installations. Previous installations of this type of system have demonstrated that such propulsion systems are most suitable for hopper dredge applications from the standpoint of being

able to effectively provide full power during all three modes of operation (i.e. trailing suction dredging, free-running loaded to the disposal site and free-running light returning to the dredging site). In addition, this type of system provides a less costly installation that is lighter in weight and takes up less space than diesel-electric systems of comparable power, speeds, flexibility and control. The availability and efficient use of full propulsion power during dredging operations afforded by CP propeller systems ensure the capability of being able to work effectively against strong currents (4 knots or more) as required in certain navigation projects.

The three new dredges are powered by medium high speed diesel engine driving CP propellers through reduction gearing. The engines on the WHEELER have a rated rotative speed of 600 rpm, those on the ESSAYONS 900 rpm and those on the YAQUINA 1,225 rpm. On the WHEELER each of the two propellers will absorb 5,000 shp, on the ESSAYONS 3,350 shp and on the YAQUINA about 1,050 shp.

Steering and Maneuvering Systems

In view of the fundamental nature of their operations, seagoing hopper dredges must necessarily be highly maneuverable vessels capable of turning within relatively narrow navigation channel prisms. The Corps of Engineers has long recognized this requirement and all of its hopper dredges are provided with twin screw propulsion and twin rudder power steering systems.

In addition, several of our dredges are equipped with bow thrusters, with the first such installation on

- Hopper Distribution Systems - Hopper distribution systems have been a source of much discussion and some significant disagreement among hopper dredge designers and operations managers over the years. Consequently, this element of the dredging systems on the three new dredges was given considerable attention during the design development.

In view of its small hopper space, the YAQUINA is provided with a very simple system that essentially consists of a single pipe discharge located in the center of the hopper that is equipped with a rotatable flexible outlet remotely controlled from the DCO station. This system is patterned after a similar arrangement on the Corps' 500 CY (382.3 CM) dredge PACIFIC which proved to be most effective and relatively maintenance free.

The ESSAYONS and the WHEELER are provided with systems which consist of two pipes running longitudinally over the hopper section with connections, bypasses and outlets at the forward and after ends that permit control of the discharge at either end of the hoppers and on the port or starboard sides. Factors that were given major consideration in developing the system installed on the ESSAYONS and WHEELER

included the need for control of material distribution in the hoppers as well as ensuring means of satisfactorily controlling draft and trim during all stages of the loading process. This aspect was especially important in view of the significant light trim forward that is generally characteristic of seagoing hopper dredge arrangements with the house and superstructure aft. The selected arrangement, in conjunc- tion with variable type overflows located at the forward and after ends of the hoppers, provides optimum control of the flow of dredged material into and through the hoppers to promote settlement of solids. Thus it provides for the flexibility required to ensure the economic loading of diverse bottom materials that vary over a wide range of density and grain size as well as the capability for controlling hopper loading and vessel trim under all types of operating conditions.

- Hopper Overflow Systems - All three of the new seagoing hopper dredges are being provided with variable level overflow systems which readily permit adjustments to obtain optimum loading of dredged materials. This feature is required to handle those materials that are readily retainable such as heavy coarse-grained sand, by taking advantage of the burnout of consumables.

The variable overflows are large vertical cylindrical sections that penetrate the hull bottom through which the overflow is discharged. The upper section of the cylinder is telescoped into a lower fixed section and is moved up and down by hydraulic cylinders for adjustment of the overflow level.

On the ESSAYONS and the WHEELER, the overflow cylinders are tapered out at the top to form a large circular weir while on the YAQUINA the upper section forming the overflow basin is rectangular. The individual overflows are remotely controlled from the Dredge Control Officer station in the pilot house. On the two larger dredges, control of the overflow levels is also incorporated in the automation system governing the hopper loading process. Conventional fixed overflows discharging through the hull sides just below the waterline and located at the uppermost level in the hoppers are also being provided on the ESSAYONS and the WHEELER for use when conducting agitation dredging in conjunction with hopper loading by deliberately pumping well beyond economic loading limits as

well as when dredging and hauling relatively light and fine-grained material or when topping off the hopper load.

- Hopper Dumping System - One of the basic design criteria for Corps seagoing hopper dredges is that the dump doors in the open position should not extend below the ship's bottom. This feature is especially important in view of the need for the Corps dredges to operate under difficult conditions while responding to defense and emergency requirements. Also, asymmetrical hopper slopes are provided to minimize the bridging of material over the bottom dumping doors.

  In addition to incorporating these fundamental features in the design of the dumping systems of the three new dredges, the size of bottom dumping door openings were increased to the maximum permitted by the structural design. Accordingly, the YAQUINA has a total of six bottom dumping door openings each 6 feet 9 inches by 3 feet 8 inches (2.06 meters X 1.12 meters). The ESSAYONS and the WHEELER have twelve and fourteen door openings, respectively, each 8 feet by 8 feet 3 inches (2.44 meters X 2.50 meters).

The new dredges have substantially greater overall areas of door openings in relation to hopper area and volume than any of the Corps existing hopper dredges. As a result the time required to dispose of the dredged materials has been significantly reduced on the three new dredges. Also, in this regard, hopper jetting systems are provided that can be employed for hopper washdown to facilitate dumping of certain materials as may be required. The bottom dumping doors on the two larger dredges are hydraulically operated and those on the YAQUINA are electrically operated and, in each case, remotely controlled from the pilot house.

- Hopper Pumpout System - As previously indicated, both the ESSAYONS and the WHEELER are equipped for direct pumpout operations. A number of the Corps' existing dredges were similarly equipped and this type of operation has been engaged in frequently over the past twenty-five years. This experience significantly influenced the pumping power plant and the design of the hopper collection systems on the new dredges.

The pumping plants on the ESSAYONS and the WHEELER were designed to pump material through long discharge

pipelines to diked containment areas and for beach nourishment requirements, where sand must be pumped through long discharge lines of at least two miles without the use of booster stations. With the inboard dredge pumps operated in series, we have provided for the long distance pumping requirements.

With respect to collection systems, a number of different arrangements and configurations were considered. Ultimately, we decided that the best system adapatable to the Corps' requirements for direct pumpout operations is one which consists of a closed pipe collection main running longitudinally through the hopper voids with branch connections (with valves) into the individual bins of the hoppers and to a seachest which is needed to provide dilution water. This system is similar to that installed on the Corps' seagoing hopper dredge McFARLAND which has proved to be quite successful. On the three new hopper dredges we have installed velocity metering devices and a means for injecting high pressure jetting water directly into the collection piping as necessary to prevent plugging of the discharge pipeline when handling dense sand.

Automation

Extensive automation of ship and dredging machinery was provided for in the design of the three new hopper dredges with the objective of reducing operating crews to a minimum as well as attaining more effective control of dredging operations. The vessels were inspected and classed by ABS with Maltese Cross ACCU certification which permits operation of the ship's machniery plant with no engine room personnel in attendance. However, during the initial year or so we will be operating with an engineering officer in the central engineer control room to monitor machinery operations. The crew complements shown in Table 1 reflect this arrangement. Therefore, we expect to make some further reductions in the crew sizes in the future. With respect to the dredging machinery and equipment, all systems will be under the control of a single Dredge Control Officer who will be stationed on the bridge of the vessels.

On the YAQUINA, the dragarm handling operation is completely automatic from the stowed position on deck to the dredging position, during the dredging cycle, and return to the stowed position. The automatic controller can be over-ruled by stop or manual

commands during any phase of the operation. In addition to automatic operation of the dragarms, instrumentation of the dredging process is provided to indicate and record dredge pump vacuum and pressure, discharge velocity, density and solids flow rate, hopper load and draft for guidance of the Dredge Control Officer.

The ESSAYONS and the WHEELER are similarly equipped for automatic dragarm operation. In addition, the dredging systems on these two dredges are automated to the maximum practical extent. Automatic devices are provided that:

- Permit selection of the dredging mode, (e.g. hopper loading, agitation dredging, direct pumpout, etc.) to be employed with subsequent automatic positioning of the valves involved.

- Keep the draghead from drifting under the hull.

- Govern hopper loading by raising and lowering overflow levels forward or aft, port or starboard, in response to preset instructions and to vessel trim, list and draft.

- Control the hopper dumping operation by opening dump doors in timed sequence pursuant to preset instructions.

- Effect unloading control and prevent line plugging during direct pumpout operations.

Deck Machinery and Equipment

Seagoing hopper dredges are equipped with deck machinery and equipment (e.g. anchors and anchor windlasses, deck fittings, lifeboats and davits, life rafts, etc.) as required by regulatory bodies for ships of comparable size. In addition, in many cases, the means for hoisting and handling heavy components and parts of the dredging system were provided. This capability is essential since defense and emergency missions may require assignments in remote and isolated regions. Also, the direct pumpout operations require frequent docking and undocking so automatic tension mooring winches are needed. Cognizance of all of these needs were considered in the design of the three new dredges.

On the YAQUINA, two electro-hydraulically powered, pedestal-mounted deck cranes of the revolving turret type were provided in the hopper section area, each with a lifting capacity of 2.9 short tons (2.6 metric tons) working at a radius of 15 feet (4.57 meters). On the ESSAYONS, a similar self-powered pedestal-mounted, but substantially larger unit, with a lifting capacity of 42 short tons (38.1 metric tons) at a radius of 45 feet (13.72 meters) was provided. On the WHEELER a self-powered level luffing revolving crane mounted on a

rolling gantry with a lifting capacity of 20 long tons (20.32 metric tons) at a maximum working radius of 60 feet (18.29 meters) was installed.

Since both the ESSAYONS and the WHEELER are equipped for direct pumpout operations, they are provided with mooring systems designed to facilitate docking and undocking. The WHEELER is provided with four automatic eletric-powered constant tension type mooring winches designed for wire rope mooring lines and remote-controlled from stations on deck fore and aft. In view of the expectations that the ESSAYONS will be assigned to direct pumpout work that will require mooring in relatively rough waters, it is provided with a mooring system specifically designed for rough water service that utilizes automatic constant tension winches. In addition, braided synthetic fibre ropes are installed to facilitate handling from the dredge to a jack-up type mooring barge. Winch control on the ESSAYONS system is from a console located on the starboard side of the bridge; and a closed circuit television system is provided for monitoring the various mooring lines from that station.

Waste Heat Recovery

Previous efforts have been made by the Corps to improve the overall fuel efficiency of its hopper dredges such as the installation of waste heat boilers in the diesel power plant exhaust system on the dredge McFARLAND built in 1967. Such installations proved to be operationally impractical due to problems that arose with associated control equipment and oftentimes as a result of an overabundance of steam. In light of the continuing need to conserve energy and in the interest of developing a practical shipboard application suitable for hopper dredges, the ESSAYONS has been provided with a somewhat different steam generating system that employs waste heat. The exhaust from each auxiliary generator diesel is fitted with a heat recovery silencer which serves as an economizer in conjunction with a fuel oil fired auxiliary boiler. Under normal operating conditions, the fuel fired boiler provides only sufficient heat to make up the difference between the waste heat economizer output and the required steam flow. The exhaust from the ship's auxiliary generator engines was selected rather than the main propulsion or dredge pump generator engines so that steam will be continuously available, including when the ship is moored or at anchor. Space constraints within the machinery spaces also dictated this selection.

On the YAQUINA, a waste heat recovery type desalinator (evaporator) system, is provided that utilizes the hot jacket water in the propulsion engine cooling system as the heat source and is designed to distill brackish sea water for potable and other fresh water needs.

CONCLUSION

It is hoped that this paper will serve to provide broad and general descriptions of the principal characteristics and design features of the three new hopper dredges recently constructed by the Corps of Engineers. These new dredges form the nucleus of a modern, minimum Federally-owned fleet that will be operated and maintained at high technological standards. Accordingly, they are equipped with modern

marine power plants and automatic control systems covering essentially all elements of ship machinery and the hopper dredging process and incorporate the latest state-of-the-art in computers and other electronic devices designed especially for such applications. It is hoped that the operational experience of these dredges will contribute to the development of more effective hopper dredging operations and the enhancement of related technology.

Table 1

Physical and General Data

		WHEELER	MCHD	YAQUINA
Length		409 ft. (124.66m.)	350 ft. (106.68m.)	200 ft. (60.96m.)
Breadth		78 ft. (23.77m.)	68 ft. (20.73m.)	58 ft. (17.68m.)
Depth		39.5 ft. (12.04m.)	35 ft. (10.67m.)	17 ft. (5.18m.)
Design Draft (Loaded)		29.5 ft. (8.99m.)	27 ft. (8.23m.)	12 ft. (3.66m.)
Gross Tonnage (est.)		11990	7728	2314
Hopper Volume		8400 CY (6423 CM)	6000 CY (4588 CM)	825 CY (631 CM)
Sand Capacity		6000 CY (4588 CM)*	4965 CY (3796 CM)*	719 CY (550 CM)**
Propulsion Power		2-5280 Hp each	2-3600 Hp each	2-1125 Hp each
Speed (Loaded)		14.5 Knots	13.4 Knots	10.0 Knots
Dredging Depth (Max.)		80 ft. (24.4m)•	80 ft. (24.4m.)	45 ft. (13.7m.)••
Dredge Pumps:				
DRAGARM MOUNTED	Number	2	2	-
	Discharge Diameter	26 in. (660 mm.)	26 in. (660 mm.)	-
	Power	1600 Hp each	1450 Hp each	-
INBOARD	Number	2	2	2
	Discharge Diameter	30 in. (762 mm.)	26 in. (660 mm.)	16 in. (406 mm.)
	Power	1800/3600 Hp each+	1500/3000 Hp each+	565 Hp each
Crew Complement		40	38	28

Notes:

*Based on Sp. Gr. 2.0 sand

**Based on Sp. Gr. 1.8 sand

+Electric motor drive designed for dual power operation w/higher power indicated for direct pumpout operation.

•Dredge is also equipped with a 42 in. (1,067 mm) diameter center dragarm capable of dredging to 60 ft. (18.3m.)

••With dragarm extension capable of dredging to 55 ft. (16.8m.)