UNITED STATES COAST GUARD HIGH SEAS OIL CONTAINMENT SYSTEM (HSOCS)*

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ABSTRACT

A detailed technical description of the High Seas Oil Containment System (HSOCS), presently being procured by the U.S. Coast Guard for operational use, is presented. Fifteen of the systems are scheduled for completion of delivery by March 1974. Each of the major subsystems of the HSOCS is described in detail. The HSOCS will be part of the equipment inventory of the Coast Guard Strike Teams of the National Strike Force for use in response to major oil spills on the high seas.

Fifteen of the U.S. Coast Guard High Seas Oil Containment Systems (HSOCS) have just recently been delivered to the USCG Strike Teams, National Strike Force, for operational use. The HSOCS consists of a great many components and is best described by separation into the following subsystems:

A. barrier subsystem
B. container subsystem
C. mooring subsystem
D. handling subsystem
E. air delivery equipment.

These subsystems are addressed in detail below.

A. Barrier subsystem

This subsystem consists of the barrier proper and represents the end result of development and testing by the Office of Research and Development, USCG Headquarters, Washington, D.C., and additional engineering improvements by the Office of Engineering, Ocean Engineering Division, USCG Headquarters. The unit length of each barrier is 612 ft. When deployed in the water, the barrier has a freeboard of approximately 21 in and a draft of approximately 27 in. The barrier is configured and constructed to achieve the major operational goals of (1) containing oil in 5-foot waves, 20-knot winds, and 1-knot currents, (2) compactness in storage and transit, and (3) strength to survive 10-foot waves 40-knot winds, and 2-knot currents.

The goal of operation in waves placed a high priority on the ability of the barrier to possess the necessary dynamic wave-following response characteristics. This goal, as well as the others cited, has been achieved by the utilization and configuration of major components of the barrier described in detail below.

Curtain. The curtain material is a 2-ply elastomer-coated nylon fabric. It is 48 in wide and provides the necessary freeboard and draft. The curtain material has a breaking strength of 650 lbs/in and a tear strength of 150 lbs/in. The coated weight of the curtain is approximately 39 oz/yd^2. The curtain also has top and bottom hems containing 1 in-wide 4,000-lb-test, nylon webbing for additional strength. Located between each rigidizing strut are 3 fiberglass stiffener battens, ¼" in diameter, that are sewn in vertical pockets the full height of the curtain and provide vertical rigidity to the approximately 5 ft of curtain located between each strut.

Rigidizing strut. One of the key early properties found to be required of a barrier designed for use in waves was that the load on the curtain containing the oil should be kept to a minimum. Any significant load in the curtain resulted in a rigidness of the curtain that negated effective wave-following performance. To achieve this desired light loading of the curtain, an external main tension line is utilized and is described in detail later. To provide a connection point for lines transmitting load to the main tension line, and also to provide a physical location for barrier flotation, a rigidizing strut (figure 1) is present every 6 ft. The strut is constructed from 1¼ in-square tubular steel in the shape of a 4-ft high, 22-in wide rectangle with slightly curved top and bottom sections. Clamps are provided for the attachment of the flotation bag and fittings are provided for the attachment of various lines. The curtain material is connected to the strut via a clamp running around the periphery of the strut. Solid foam buoyancy is also present to ensure proper orientation of the strut just prior to inflation of the flotation bag during deployment.

Flotation bag. To achieve the compactness in storage, with resulting larger amount of barrier per unit volume, and to provide the necessary buoyancy and wave following properties to the barrier, a CO_2 inflated flotation bag is attached to each strut. The flotation bag, when inflated, is approximately cylindrical in shape with a 13-in diameter and a 4-ft length. It is attached to the strut at the end of the cylinder on one side only, at right angles to the strut, via a clamp to the bag fabric. The flotation bag is constructed from a heavy-duty, elastomer-coated fabric having a coated weight of approximately 60 oz/yd^2. To transmit the necessary righting moments to the strut, and thus the curtain, bag tie-down lines are connected between the bag and the top and bottom of the strut by nylon webbing loops (lines on bag are from top underside). These lines are of a length such that, when the bag is properly inflated, motion of the bag is transmitted to the strut. This maintains the 90° connection of the bag to the strut and results in the strut and curtain being maintained at 90° to the waters surface as the bag rides the waves. The flotation bag also has a lace-in pocket and necessary fittings for the attachment of the CO_2 bottle and inflation valve.

Dynamic ballast bag. On the far end of the flotation bag, away from the strut, a dynamic ballast bag is connected on the underside of the flotation bag by lacings and grommets in the flotation bag. This bag is approximately 1 foot in diameter and 18 in high. In the bottom of the bag, which is constructed of coated fabric, is a circular lead plate which provides the necessary counterbalancing of

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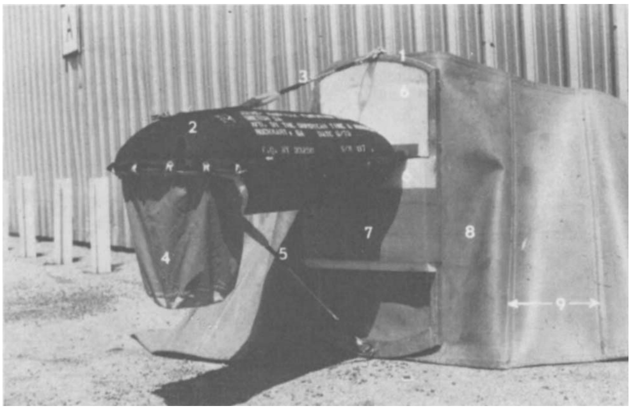

Figure 1. Rigidizing module unit of modified barrier viewed from non-oil side. (1—Strut, 2—Inflatable, 3—Tie-down (Upper), 4—Ballast Bucket, 5—Tie-down (Lower), 6—Solid Flotation Pads, 7—Lower Pad Retainer, 8—Curtain, 9—Battens.)

the weight of the strut on the other end of the bag. The ballast bag is free-flooding upon deployment, and the weight of the retained water inside the ballast bag assists in this counterbalancing during roll of the bag and strut in waves.

CO_2 bottle-inflation valve. To provide the necessary source of CO_2 during inflation of the flotation bag, a standard, 30-cubic-inch bottle is connected to the bag via an inflation valve. The bottle is charged with approximately 8.5 oz of CO_2 and, upon inflation, this weight of CO_2 creates an internal flotation bag pressure of between 5-6 psi. Such a pressure results in an extremely rigid flotation bag and allows for effective transmission of bag motion to the strut via the bag tie-down lines. To accomplish the activation of the bottle during deployment of the barrier, a lanyard-operated puncture-type inflation valve was developed for installing on the bottle. Upon lanyard pull (approximately 50-100 lbs is required), the valve punctures the bottle and inflation of the bag occurs.

Main tension and bridle lines. The main load-carrying member of the barrier is the main tension line (figure 2) and consists of a 1 5/16-in diameter double braided synthetic line. In addition to providing the necessary strength to the barrier, this line also possesses elongation properties that assist in meeting the necessary surge response requirements for the entire 612 ft of barrier when in the presence of waves. The surge response of the barrier is in the direction of the waves and is necessary to maintain the oil-barrier contact as the oil-water surges in that direction. The main tension line is connected to each rigidizing strut by 3 bridle lines. Two of these bridle lines connect to the approximate side midpoints of the strut while the third is connected to the bottom of the strut, thus allowing the transfer of curtain loading to the main tension line without inducing any undesirable loads on the barrier that would affect its

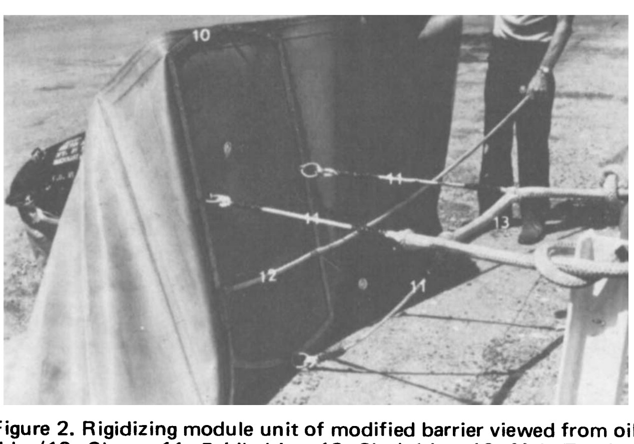

Figure 2. Rigidizing module unit of modified barrier viewed from oil side. (10—Clamp, 11—Bridle Line, 12—Slack Line, 13—Main Tension Line.)

wave following properties. The bridles lead from the oil side of the barrier and connect at 90° angles to the main tension line. These are the only components of the barrier that are located on the oil side, and they have a negligible effect as far as disturbing the oil-water-curtain interaction is concerned.

Slack retainer line and barrier extension lines. To provide a means for connection to moorings or for towing, each end of the main tension line is attached to approximately 140 ft of identical material extension line. The extension line also, through it elongation properties, assists in providing the necessary surge response to the barrier. Each of the extension lines terminates with the appropriate fitting for making connections to moorings.

B. Container subsystem

This subsystem consists of a structural aluminum container that is used to store, transport, and deploy the barrier subsystem. It is essentially of rectangular shape and has dimensions of 18 ft long × 9 ft wide × 5 ft high. The empty weight of the container is approximately 4,600 lbs. The floor of the container is a air transportable-air droppable pallet that is compatible with the – 4A rail system presently installed in CG C-130 aircraft. Each container holds 612 ft of barrier. Two of the containers can be transported in one C-130.

The container is white in color, except for the roof which is an international orange nonskid surface. The roof of the container consists of 3 removable sections that are bolted in place. The aft end of the container is a removable hinged tailgate. Both the roof sections and the tailgate are removed during repacking of a barrier subsystem into the container. During the deployment of the barrier from the container in the water, only the tailgate is removed with the barrier all coming out of one end. Permanent solid flotation material in the roof sections provides the necessary buoyancy to float the container with approximately 6 in of freeboard. This freeboard is essentially the same whether the barrier is present or not due to the barrier being only slightly positively buoyant prior to inflation of the flotation bags. The front end of the container is equipped with a bridle that allows the container to be towed at speeds up to 5 knots. Also present as part of the container subsystem is a coated fabric protective cover that affords weather protection to the container during storage.

Fittings are provided on the container for the attachment of a hoisting sling. These same fittings are also used for the attachment of risers leading to parachutes when the container is rigged for air-drop delivery. All other fittings necessary for placement and configuration of all required air-drop equipment are also present. The container has been air dropped several times with barrier inside and has demonstrated its ability to withstand the associated loads and water impact without sustaining any significant damage. Details of the air-delivery equipment are contained in later paragraphs. Necessary fittings for the packing and retention of the barrier subsystem within the container are also present.

The barrier is packed into the container in vertical accordian-type flakes or folds. There are 34 flakes for each loaded barrier when in the container. To assist in maintaining proper position of the barrier components for deployment, each rigiding strut is held in position by the use of wooden retention blocks. These blocks are grooved to fit underneath and on top of each strut. The lower blocks rest in channels in the container that run the full length of the container. The upper blocks are doweled into a plywood ceiling. This retention system also prevents any large cumulative load from being developed on the container during handling and is particularly necessary during the motions of the container during air-drop.

Leading from each of the CO_2 bottle inflation valves is a lanyard which connects to a permanently attached cable running the full length of the container. Deployment of the barrier is caused by a tow vessel or other external means connecting to one of the barrier extension lines (terminated at a fitting on the top of the container for easy access). As this line is pulled, the tailgate is removed from the aft end of the container. The tailgate floats and remains tethered to the extension line for later recovery. Further strain by the towing vessel results in the barrier being pulled from the container. As this occurs, the lower retention blocks slide in the channel, and the upper blocks come free. As each strut clears the container, the lanyards to the CO_2 inflation valves go taut and the CO_2 discharges into the flotation bags on the barrier. This process of sequential firing and filling of the flotation bags continues until all 612 feet of the barrier is removed from the container. Total deployment of the barrier requires approximately 5 minutes.

C. Mooring subsystem

To provide for the permanent positioning of the barrier when in the water, after deployment, a mooring subsystem is included in the HSOCS. This subsystem consists of buoy, lines, anchor, and miscellaneous fittings. The mooring buoy is a 500-gallon rubberized storage container that is fitted for CO_2 inflation by a 10-pound CO_2 bottle and hand-activated inflation valve. The inflated dimensions of the buoy are approximately 5 ft long × 1 4½ ft diameter cylinder. Circumferential stripes, international orange and white, are present on the buoy to aid in locating it in the water. One end of the buoy is equipped with a cable bridle for attachment of the barrier extension line. The other end of the buoy has a swivel fitting for connection of the synthetic line leading to the anchor and chain. The synthetic mooring line is provided in rod lengths of 210 ft, 390 ft, and 600 ft to allow for mooring the barrier in various depths from 35 ft to 200 ft using a 6 to 1 scope. The anchors are standard Danforth type anchors. Dependent on the anticipated bottom and weather conditions, one or more anchors can be connected to each buoy.

All components of the mooring subsystem are packaged in a plywood container in such a manner as to allow easy selection of desired lengths and assembly of all components. Deployment of the mooring subsystem is accomplished from an appropriate surface vessel either before or after barrier deployment. One mooring subsystem is needed for each end of the barrier, i.e., each mooring subsystem consists of one buoy, one anchor, etc.

D. Barrier handling subsystem

The average weight per foot of the barrier subsystem is 16 pounds. However, the construction of the barrier is such that this weight is concentrated at the rigidizing struts located every 6 ft along the barrier. This results in each strut area encompassing approximately 100 pounds in weight. This obviously presents difficulties in the handling and retrieval of the barrier after use.

To alleviate this problem, a barrier handling subsystem has been developed to assist in the retrieval, transporting, refurbishment, and cleaning of the barrier after operational use. The essential features of the barrier-handling subsystem are (1) a powerized retrieval mechanism consisting of lines attached to the barrier that lead to a hydraulic-driven winch which assists in pulling the barrier aboard; (2) a conveyorized container that receives the retrieved barrier via overhead rails; and (3) a sequence of A-type frames which facilitate the cleaning and refurbishing of the barrier upon return to base. The container is compatible with the anticipated modes of transport back to base, i.e., by highway, C-130, or some other means.

Deployment. Owing to the operational environment for which it was designed, operations and logistics associated with the HSOCS are of a distinctly more complex nature than those associated with barrier usage in a relatively calm harbor environment. As stated previously, the HSOCS has been developed and successfully tested to include the capability of aerial delivery from CG C-130 aircraft. Surface delivery via the appropriately sized and equipped craft is also available. The best suited vessel for such a surface transport and deployment of the barrier, within the Coast Guard Inventory of vessels, is the 180-foot seagoing buoy tender. Any other commercial surface-delivery vehicle must possess the required deck space for transport and, in addition, the crane or boom capability to lift the approximately 17,000-pound loaded container and to deliver it to the surface of the water.

Once delivered to the surface of the water, deployment of the barrier is accomplished in exactly the same manner irrespective of the delivery mode. The general sequence of events and vessels required is presented below.

A tow vessel, capable of operations in the designed sea state, is required to connect to the bridle assembly located on the forward end of the loaded container subsystem. Personnel are required to board the container to accomplish several disconnect of lines. The first action required is the disconnect of one end of the barrier extension line from its tied-off position on the top aft end of the container. This end, with its attached fitting, is passed to a tow vessel or connected to a previously deployed buoy of the mooring subsystem. The vessel connected to the towing bridle of the container then proceeds to tow the container. Personnel trip the fittings that release the aft tailgate (the tailgate remains tethered to the extension line for later on recovery). As the towing vessel proceeds, the strain in the extension line causes the barrier to commence deployment from the container. As each rigidizing strut clears the aft end of the container, the previously attached static lines from the CO_2 cylinders to the interior cables of the container go taut, discharging the CO_2 into the flotation bags and deploying the barrier. This process continues until all 102 flotation bags have deployed. After this, the container tow vessel proceeds, with container still in tow, to the other mooring buoy or tow vessel. Personnel on the container release a lazy-leg of the remaining barrier extension line for attachment to the buoy or vessel. This lazy-leg feature allows the container to remain attached to the extension line until the strain in the barrier is picked up by the barrier extension line. After this occurs, personnel on the container then release the lazy-leg to the container, and the container is towed away for return to port or recovery. This deployment operation takes approximately 15 to 30 minutes. Owing to the danger potential, qualified divers are necessary to accomplish the above disconnect of lines on the container.

E. Air delivery equipment

The HSOCS was designed and successfully tested to be capable of loading aboard a CG C-130 aircraft fitted with the appropriate interior rail system, flown to the scene of the spill, and then aerially delivered to the surface of the water. To accomplish this mission, the HSOCS includes the following major components of air delivery equipment.

Load extraction system. To accomplish extraction of the loaded container subsystem from the aircraft in flight, a heavy duty 28-ft ringslot extraction parachute is used. The extraction chute is mechanically deployed by the aircraft crew at the proper time and altitude to achieve desired area of water impact.

Main recovery parachutes. After extraction of the container subsystem from the aircraft, the safe descent of the container is provided by the main recovery parachutes. These chutes are deployed after the load has cleared the aircraft via the load transfer system. The chutes consist of 4 each standard G-11A, 100-foot diameter canopies. These chutes result in an impact velocity on the water of approximately 20 ft per second.

Load transfer system. As the loaded container subsystem leaves the aircraft, a system of cables and fittings activates a knife cutter located on the aft end of the container. This knife cutter transfers the load from the extraction chute to the deployment of the main recovery chutes after the loaded container has safely cleared the aircraft. In addition, this load transfer system prevents premature deployment of the main chutes in the aircraft without required movement of the container aft and out.

Temporary mooring system. On the front end of the container, inside the splash shield, is housed a temporary mooring system. This system is designed to deploy at water impact and provides temporary mooring of the now floating container to prevent movement prior to the arrival of surface vessel and personnel. It consists of a mooring buoy made from 55-gallon drums, necessary lines and fittings, and a 65-pound Danforth-type anchor.

Parachute and temporary mooring-release mechanism. Upon water impact, it is desirable to separate the main recovery parachutes from the container and also to deploy the temporary mooring system. This is accomplished by a mechanical-pyrotechnic system which functions upon relaxation of the load in the main parachute risers. This device is located at the point of attachment of the harness sling from container and the risers from the parachutes.

At the same time as main parachute release, restraining cables holding the temporary mooring system in place are also released allowing the mooring system to deploy.

All of the above components, together with other necessary fittings and rigging, are rigged to the loaded container subsystem either while in storage or prior to flight. This rigging of the air delivery equipment is a complex evolution requiring the services of highly-qualified loadmasters and technicians and will not be described further in this paper.

Summary

The preceding describes in detail all subsystems and major components of the HSOCS. At the time of writing, 6 each of the barrier subsystems and containers subsystems had been delivered. Delivery of the remaining 9 barriers and containers is anticipated by March 1975. Delivery of 18 of the mooring subsystems was to be accomplished by December 1974. All necessary spare parts, tools, and other equipment required will also be delivered. This will provide the CG Strike Team with a HSOCS capable of surface delivery to the scene of a major oil spill. Delivery of the air delivery equipment is anticipated during the summer of 1975 pending completion of additional modifications and testing.

As of the writing of this paper, the ultimate specific siting plan for the fully equipped HSOCS had not yet been determined, although it is planned to distribute the systems on the East, West, and Gulf Coasts. Responsibility for the maintenance and operational deployment of the HSOCS will reside with the CG Strike Teams.

In summary, the Coast Guard now has a system of equipment designed to combat major oil spills on the high seas. This HSOCS has its shortcomings; however, it is capable of a significant contribution to the containment of oil spills, and as such, is a significant addition to the Coast Guard inventory of equipment to alleviate damage from major oil spills.