A HYDRODYNAMICALLY EFFECTIVE HORIZONTAL OIL BOOM

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ABSTRACT

Conventional vertical barrier booms are ineffective in currents in excess of approximately 0.7 knots when placed at right angles to the current. The PACE boom is a horizontal boom that is effective in medium to fast currents and has successfully been tested on the St. Lawrence River in currents of 2.5 knots.

It is a hydrodynamically effective horizontal oil boom that utilizes the natural forces of flowing water to contain spilled oil and/or direct it for recovery. A section of boom consists of two parallel flotation devices each 15 m in length and joined by a suspended segment of netting fastened to a fabric through which water passes but not oil. In operation, interconnected sections of boom are placed across the current in such a manner that surface oil flows under the first flotation device, up through the netting, and over the fabric where it is trapped against the second flotation device. A tangential flow produced between the floats carries the oil across the current to a recovery area.

INTRODUCTION

The Petroleum Association for Conservation of the Canadian Environment (PACE) is comprised of representatives of eleven major Canadian oil companies. With their financial assistance and encouragement, the PACE boom was developed over a period of two and one-half years by Steltner Development and Manufacturing Company, Limited. Because of its inherent characteristics, considerably less PACE boom than conventional boom is required to contain oil on water in a given set of conditions of current, wind, and waves, and it is relatively easy to deploy.

This paper describes the boom's structural and functional characteristics and the overall effectiveness of its hydrodynamic concept for containing oil spills in medium to fast currents.

Structural design

The PACE boom consists of two parallel floats of polyvinyl moulded into tubes 33 cm in diameter and 15 m in length. To protect the polyvinyl tubing, it is covered with a strong, tear-resistant nylon casing. Attached to the bottom of the upstream float is a flat multi-ply nylon webbing 4.8 cm in width and 15 m in length. The ends of this nylon webbing are looped back and sewn to accommodate a special attachment for interconnecting sections of boom, or for attaching an anchor line. All of the forces on the boom are transmitted to and through this webbing which has a working strength of 8,000 kg. Attached to this webbing is a smaller flat single-ply nylon webbing that has a nylon net attached forming a "net panel." The nylon net is a 3.8-cm knotted mesh that is sewn to the nylon webbing with a slip-loop stitch. The loops allow the mesh to change configuration in response to altered angular positions of boom and thereby the strain on each strand is equalized. Fastened to the downstream side of this net panel single-ply webbing is a section of viledon polyester. In the presence of water this material has the physical characteristics of being hydrophilic and oleophobic. The void content is such that water will stream through the material but not so high as to permit the passage of oil. The downstream side of this material is attached to another length of nylon webbing which, in turn, is attached to the downstream float. It also has looped ends for the quick coupling attachments of additional lengths of boom. Along the length of each section at 5- and 10-meter intervals is another single-ply nylon webbing that connects the strength member webbing adjacent to each float to take most of the strain off the mesh and viledon. The 15-meter sections of boom are interconnected by two mild steel couplings similar in principle to the connector on a bicycle chain. A heavy duty silver nickel zipper on a nylon tape connects the mesh and viledon to the attached sections of boom and prevents the escape of oil from between sections. Two other zippers connect adjacent sections around the parallel floats. A nylon flap held by velcro tape protects the zippers from being clogged up by particles of sand and silt. After the desired sections of boom are attached, zippered end caps are placed on each extreme end of the boom to protect the inner vinyl tubing of each end float.

Inflation

The boom is inflated through a plastic valve located at one end of each 15-meter float. The valve has a 2.5-cm aperture and a backflow-prevention flap that makes inflation quick and simple. To deflate the floats, the valve flaps are pushed in and the air quickly escapes. The valves are accessible through the nylon casing of each float and a covering flap protects them for external abrasion. A high volume, low pressure portable compressor set for 3 to 4 lb per square inch is used to fill each float in about 40 seconds. The inflated section of boom weighs 45 kg and when deployed, has a draft of approximately 50 cm at the interconnection of the nylon netting and viledon. Unlike verticle booms, the effective freeboard of the PACE boom is the horizontal distance between the two floats—about 125 cm. This effective freeboard is maintained by a component ratio of 1/3 mesh to 2/3 viledon and the relative effects of the current on the viledon and the floats (see figure 1).

Deployment

Because of the flexibility of the materials in the PACE boom, it is particularly suitable for storage on a reel in the number of preconnected sections required for an anticipated containment and recovery operation. Using a boat or tow line for deployment, the preconnected sections can be quickly and easily inflated as they come off the reel. To minimize current drag during deployment, the downstream float is laid over the upstream float. When both ends are anchored, the downstream float is flipped over, and the boom positions itself in a few seconds. It has been found practical on wide rivers to anchor one end of the boom on shore and to hold

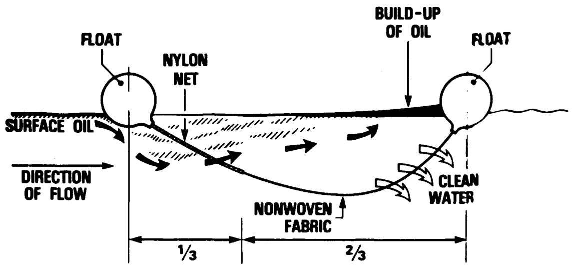

Figure 1. Cross section of boom

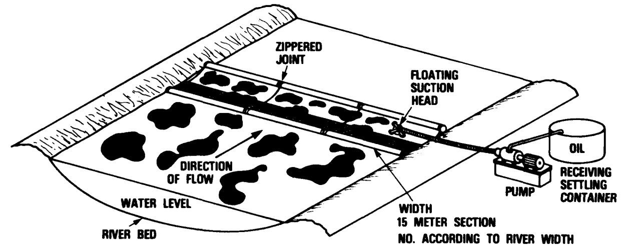

Figure 2. Deployed boom

the other end in a J configuration by means of another anchor in midstream or a suitably powered boat. The spilled oil is then diverted to a shoreline area where it can be removed using a skimmer or vacuum truck.

Functional aspects

Unlike conventional verticle booms, the PACE boom is a horizontal boom that utilizes the effective force of moving water. Spilled oil passes readily under the upstream float aided by the current and the shallow draft of the float. The oil then passes through the nylon netting and toward the water surface between the floats and above the viledon. Because of the oleophobic characteristics of this material, the oil cannot pass through, and consequently, it is contained in the calm area between the two floats against the downstream float. As a result of the boom's angular deployment and the force of the river's current, a tangential flow of water occurs between the floats carrying the oil down the length of the boom to a recovery area. Figure 2 shows this method of recovery and the use of a surface skimmer to remove the spilled oil. The effective force of the moving water is utilized to keep the floats apart to provide (1) a ponding area for oil collection, (2) a diversionary channel for the collected oil, and (3) a catchment area for any oil which might splash over the upstream float due to wave action. After use, the boom may be steam cleaned. During use at optimum angular deployment, the viledon is self-cleaning.

Conclusion

It is anticipated that further research and development work will indicate the appropriate diameter and shape of the flotation devices and optimum netting/fabric ratios for boom which will perform effectively under conditions of higher and more turbulent currents.