Appendix A
Mechanical Containment and Cleanup Technologies

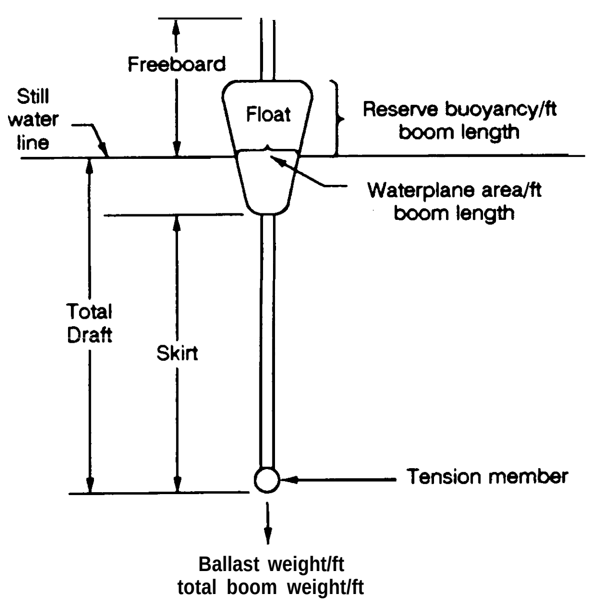
Containment Booms

Oil spill containment barriers or booms are floating devices generally resembling short curtains that restrict an oil slick from spreading beyond the barrier. Several designs have been produced for conditions ranging from protected waters to open ocean. Some barriers are designed to be towed, while others remain stationary. Barriers designed for protected waters would be less effective in strong currents or heavy waves but generally are more easily deployed than offshore booms. Oil spill containment booms generally have five operating components as shown in figure A-1.

Float

The float is the buoyancy member that keeps the boom riding on the surface of the water. Heavier booms or booms used in rough seas need more buoyancy and therefore have a larger volume of float materials. Floats may be rigid or flexible and should be relatively smooth so that they don't trap debris or produce vortices that may cause the loss of oil under the boom.

Figure A-1 -Components of a Boom



SOURCE: World Catalog of 011 Spill Response Products

Freeboard

The freeboard is the vertical height of the boom above the water. The freeboard prevents oil from washing over the top of the boom, but if it is too high, the boom may be pushed over in high winds. The boom must be flexible enough to rise and fall with the waves so that the freeboard is not lost with each passing wave.

skirt

The skirt is the continuous portion of the boom below the floats. The skirt helps to contain the oil. While a deeper skirt is more effective in containing oil, increasing skirt depth increases the current load on the tension members of the boom.

Tension Member

Tension members consist of any elements such as cables, chains, lines, or boom fabric that carry the horizontal tension loads on the boom.

Ballast

Weight is applied to the bottom of the skirt to improve boom performance. Ballast is generally a chain (which also serves as a tension member) or a series of weights along the entire length of the boom.

There are two basic types of booms in general use today: **fence booms** and **curtain booms.** Fence booms have a rigid or semirigid material as a containment screen for oil floating on the water. Curtain booms have a flexible skirt held down by ballast weights or a tension chain or cable. Their major difference is the way in which they respond to waves, current, and wind. If current and wind roll a fence boom away from the vertical, there is a loss of freeboard and draft. A curtain boom has a flexible skirt that is free to move independently of the freeboard and flotation, thus movement of the skirt away from vertical does not necessarily mean loss of freeboard. Other booms, not necessarily of different types, are designed for special purposes. These include fireproof booms, ice booms designed for spills in ice-filled water, and sorbant booms used to contain and absorb small amounts of oil in relatively calm waters.

Booms are classified according to their physical characteristics, which include freeboard, draft, reserve buoyancy to weight ratio, total tensile strength, skirt fabric tensile strength, and skirt fabric tear strength. Although all of these characteristics are important, only the freeboard and draft will be mentioned hereto convey an idea of the overall size of booms that are used for various applications (table A-l).

In the above classification, based on that used in the World Catalog of Oil Spill Response Products, calm water is defined to have a significant wave height of less than 1 foot, harbors less than 3 feet, and offshore less than 6 feet. The significant wave height is the maximum wave height for which booms in that category are likely to be effective. The table shows that booms recommended for harbors and offshore are quite large. A boom recommended for harbors would have a vertical dimension (freeboard plus draft) of 22 to 42 inches and a boom recommended for offshore use would have a vertical dimension of more than 42 inches.

These classifications should be used with some flexibility. For example, offshore booms typically have long skirts. However, in offshore areas of fast currents a shorter skirt may be more effective. In this case, a boom classified as a harbor boom maybe more suitable than an offshore boom.

Table A-1 - Boom Classification According to Freeboard and Draft

Service	Freeboard (inches)	Draft (inches)
Calm water	4-1o	6-12
Harbor	10-18	12-24
Offshore	>18	>24

SOURCE: Office of Technology Assessment, 1990

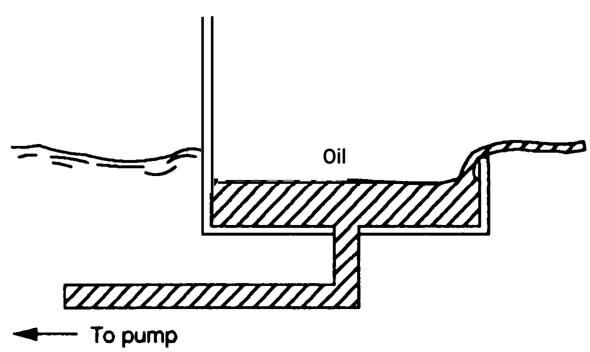
Mechanical Recovery Devices

Several devices have been developed to collect oil from surface waters. Since the efficiency of an oil recovery device is improved by increasing the thickness or depth of an oil slick, these devices are frequently used in combination with containment barriers. Oil spill recovery skimmers are generally separated into categories according to the way in which they pick up oil. Fourteen categories and subcategories can be identified. These are defined as follows:

Weir – A skimmer that has an interior basin with a slightly submerged lip over which the oil floats and is collected by gravity (figure A-2). The weir is generally a floating skimming head used with a pump to continuously empty the collecting basin. These skimmers work best if the edge of the weir is right at the oil/water interface, but in practice, this adjustment is difficult to achieve and maintain. Weir skimmers have the advantages of being simple, reliable, and commonly available. In thick layers of oil (25 mm or more), weir skimmers have high recovery rates with a recovery efficiency of around 50 per cent. In thinner slicks (1 to 8 mm), the recovery efficiency drops to 10 per cent. Conventional floating weir skimmers have problems in becoming clogged with debris and do not work well in waves. Archimedes screw devices have been incorporated in some weir skimmers to grind up debris.

suction – A suction skimmer is a simple suction head acting somewhat like a weir used on a floating hose from a vacuum truck or portable suction pump (figure A-3). Pump suction draws the oil to the

Figure A-2 - Weir Skimmer



SOURCE: World Catalog of Oil Spill Response Products.

skimmer head. This also is the same principle used when a suction hopper dredge is converted to oil spill recovery. The advantages of suction skimmers are that they are simple to operate, shallow draft, and can be used nearly everywhere, even under piers. They are likely to have a fairly high pumping rate but with a low recovery efficiency, particularly in a thin slick. They are not effective, however, if there is any appreciable water movement such as choppy waves.

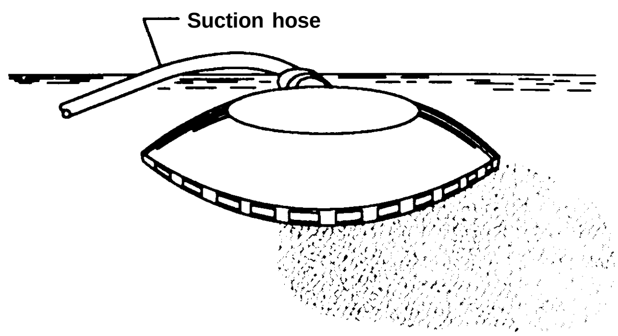
Boom Skimmer – A boom skimmer is a recovery system with one or more skimmers mounted in the face of a spill containment boom, regardless of the skimmer type, although the recovery device is generally a weir (figure A-4). Weirs installed on booms that can follow the wave surface reasonably well are kept near the surface of the water and therefore able to maintain a high rate of recovery. In general, boom skimmers have a high rate of recovery and are designed for dealing with large spills at sea. Since the weir is employed in the collection pocket of the boom, recovery efficiency is increased. Boom skimmers are large pieces of equipment with many working parts needing maintenance. They are adversely affected by the same debris problems as other weirs.

Vortex – A vortex skimmer draws oil and water into a collection chamber and separates it by centrifugal force (figure A-5). This centrifugal action discharges the water out of the bottom and concentrates the oil so that it can be pumped off through a hose to storage. This principle is sometimes combined with a weir serving as the collection chamber. Vortex skimmers can achieve a reasonable recovery rate in medium to heavy oils, but generally have a fairly low efficiency.

Moving Surface – Moving surface skimmers utilize a moving material that absorbs or causes oil to adhere to it in preference to water. The oilcoated material then passes over a scraper, squeezer, or other device to remove and recover the oil in a sump. There are several varieties of moving surface skimmers including, disk/drum, brush, rope mop, and belt types as follows:

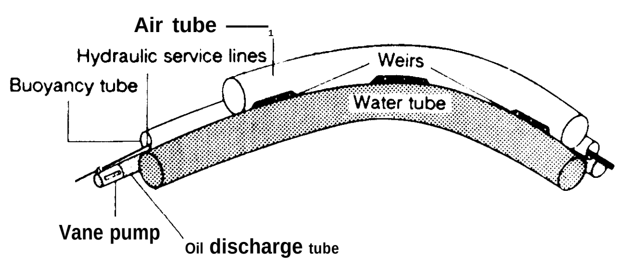
Disk/Drum– Any disk or drum devices that rely ***on*** the adhesion of oil to a solid surface (figure A-6). Disk type devices have a series of vertical disks that are rotated through the oil surface. Drum skimmers have a horizontal drum that rotates through the slick. Many small disk skimmers have the disadvantages of being expensive, complicated, more likely to break down, and vulnerable to becoming clogged

Figure A-3– Floating Suction Skimmer



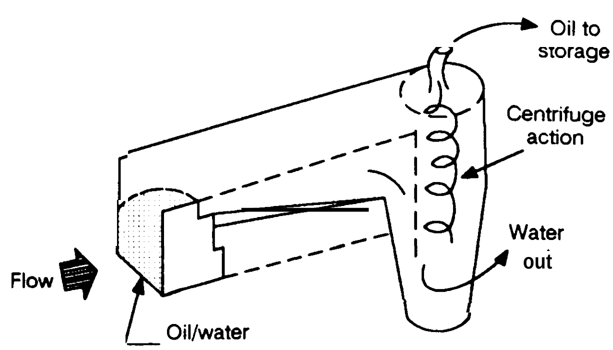
SOURCE: World Catalog of 011 Spill Response Products

Figure A-4-Schematic Drawing of a Weir Skimmer



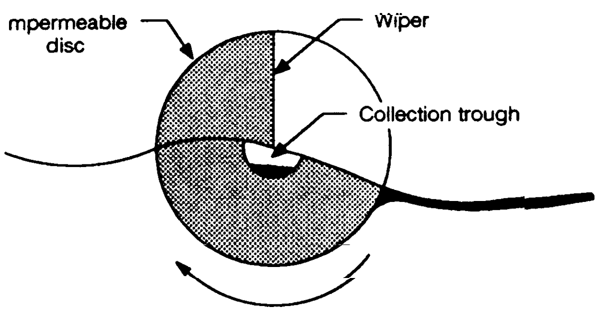
SOURCE: Vikoma International

Figure A-5-Vortex Skimmer



SOURCE: World Catalog of 011 Spill Response Products

Figure A-6- Disc Skimmer



SOURCE: World Catalog of Oil Spill Response Products

with debris. On the other hand, they have high recovery efficiency which can be a considerable advantage if storage volume is limited. Large disk skimmers are likely to be more durable and some disk skimmers have vanes or screens to keep out debris. Because of the vertical dimensions of the disk, disk skimmers are effective in waves. Some large floating disk skimmers are effective in fairly high sea states.

Brush – Skimmer with a horizontal brush that rotates through the oil and past a scraper which removes the oil into a sump. This skimmer is designed for recovering highly viscous oil and oil on ice.

Rope Mop – Rope mop skimmers employ along, continuous loop of absorbent oleophilic (oil loving) material that floats on the surface of the water and is then led through a combination scraper-wringer that removes the oil along with some water (figure A-7). Rope mops can be deployed from shore and the rope guided around a pulley that has been secured offshore or can be operated from boats. Rope mop skimmers generally have a high recovery efficiency and are most effective in medium viscosity oils. Rope mops can operate in shallow water, water filled with debris, water mixed with ice, and under ice. They are relatively easy to maintain.

Belt – Belt skimmers are identical in that they all employ a moving belt which mayor may not be of absorbent material. Six types of belt skimmers can be identified.

1. Paddle Belts – Paddles are attached to the belt to lift oil out of the water (figure A-8). A typical paddle belt skimmer pulls oil up a ramp using four or more paddles. Paddle belt skimmers have a high recovery rate and operate best in medium to high viscosity oils, but are likely to have problems in short period waves.[1] They also handle debris very well.

2. ***Sorbent Belts –*** A sorbent belt skimmer is one that has a continuous, flat belt that moves horizontally over the water in the well of the collection vessel (figure A-9). High recovery rates can be expected and debris handling is excellent. This skimmer was developed for the U.S. Coast Guard as a zero relative velocity skimmer with the belt moving as fast as the vessel is traveling forward (or current moving aft). Apparently, while technically feasible, it has not been very practical operationally and has never been commercially produced. Perhaps further development could prove useful.

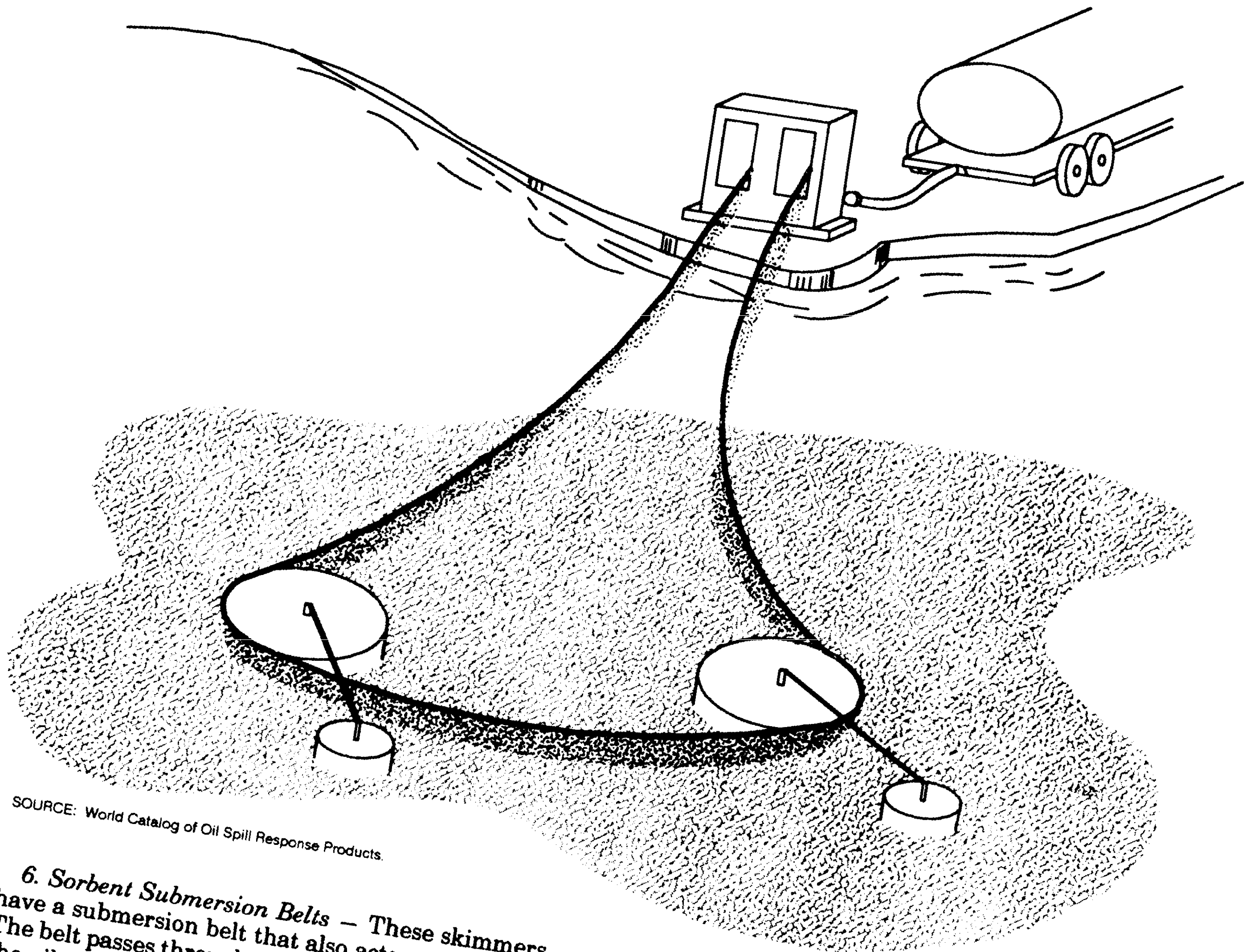
3. *Sorbent Lifting Belts –* A sorbent belt skimmer that has a belt inclined to the water's surface and lifts the oil out of the water (figure A-10). Sorbent lifting belts are made of porous oleophilic material that allows water to pass through. The belt passes through a set of rollers where the oil is scraped and wrung out of the belt. Sorbent lifting belt skimmers are often mounted on fairly large vessels and are intended for use in harbors and offshore. They can be expected to have a high recovery rate and high efficiency.

4. ***Brush Lifting Belts –*** These skimmers have a chain of brushes that lift the oil from the water. Cleaning devices remove oil from the brushes at the top of the ramp. These would be particularly useful in large spills of highly viscous oil.

5. ***Submersion Belts –*** The operating principle of submersion belt skimmers is the opposite of lifting belt skimmers (figure A-n). Instead of carrying the oil up out of the water, the submersion belt moves along a plane forcing the oil under water. The oil then surfaces in a collection sump. Submersion belt skimmers work best in low viscosity oils and thin slicks, in contrast to most other skimmers that require thick accumulations of oil for most effective operation.

[1]World Catalog, p. 226.

Figure A-7 – Rope Mop Skimmer

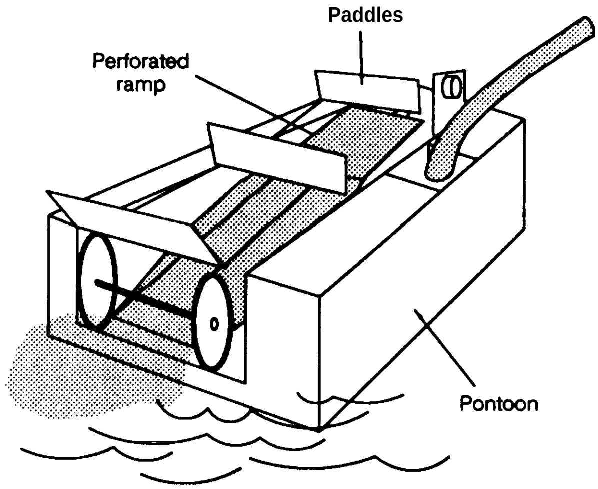


SOURCE: World Catalog of Oil Spill Response Products.

6. Sorbent Submersion Belts – These skimmers have a submersion belt that also acts as a sorbent. The belt passes through a set of rollers that remove the oil. Oil that is not absorbed is carried beneath the belt and rises in a collection chamber located aft of the belt. These skimmers are effective in light to heavy oils in thicknesses of several millimeters and work best in calm seas or moderate seas with a swell up to 3 feet.

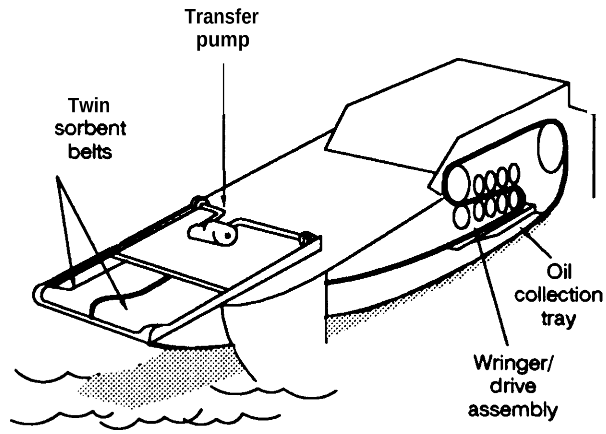
Submersion Plane – The submersion plane skimmer has a fixed plane which is advanced through the oil, submerging it and directing it into a collection area aft. It is similar to the submersion belt skimmer except that it does not have any moving parts. Submersion plane skimmers work best in light to medium viscosity oils.

Figure A-8-Paddle Belt Skimmer



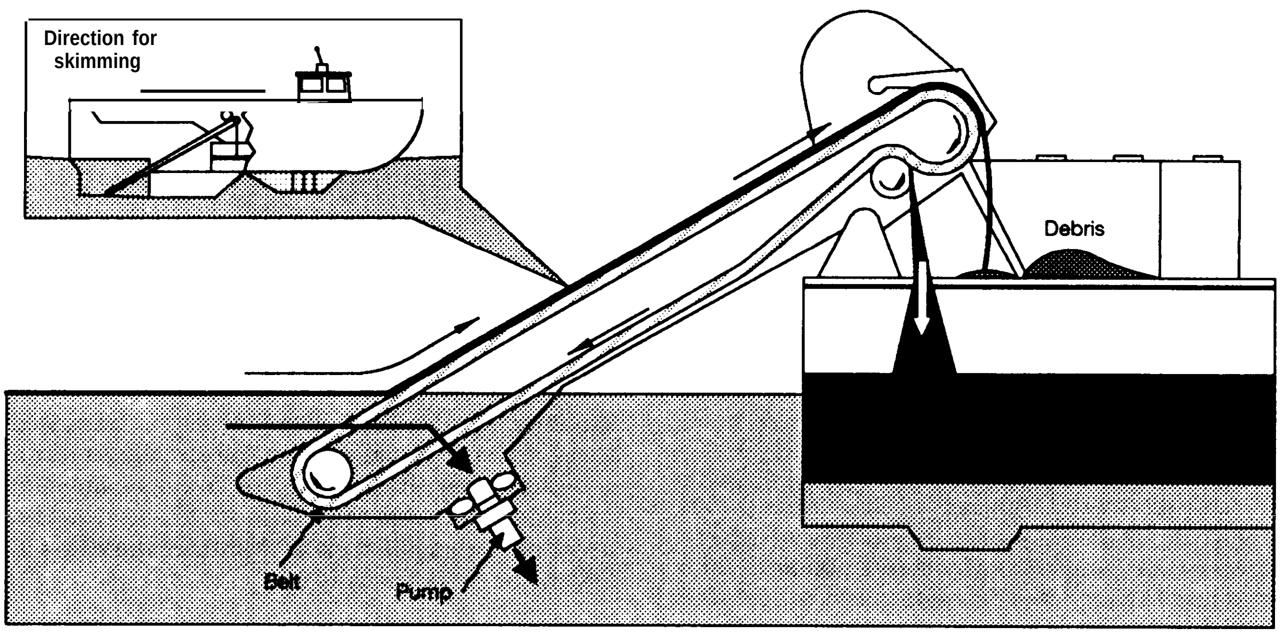
SOURCE: World Catalog of Oil Spill Response Products

Figure A-9- Sorbent Belt Skimmer



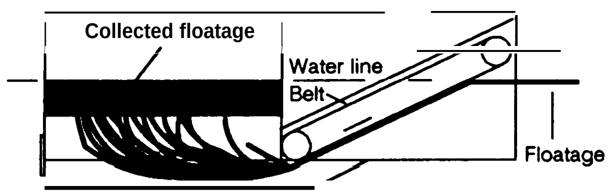
SOURCE: World Catalog of Oil Spill Response Products

Figure A-10--Sorbent Lifting Belt Skimmer



SOURCE: World Catalog of Oil Spill Response Products

Figure A-n –Submersion Belt Skimmer



SOURCE: World Catalog of Oil Spill Response Products