UNIVERSAL SUBSEA OIL CONTAINMENT SYSTEM AND METHOD

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A system, method, and apparatus for containing oil and gas leaking from an underwater wellhead or other man-made structure. The apparatus includes a conduit having an upper end and a lower end with an opening. The conduit is sized for the lower end to be positioned over a plume leaking from the man-made structure and the upper end to be substantially near or at the seawater surface. The apparatus also includes a port for introducing a suitable gas such as nitrogen into the interior of the conduit for displacing seawater from the interior of the conduit. In addition, the apparatus includes a plurality of valves for metering liquid and gas flow within the interior of the conduit. The conduit is positioned over the leaking man-made structure and oil and gas flow upward from the leaking man-made structure through the interior of the conduit.
FIG. 4A

300

Close valves on conduit

302

Conduit is submerged

304

As conduit descends, gas is introduced into interior of conduit

306

Gas injected into port of induction bell

308

Conduit positioned over plume

310

Appropriate valves opened

To FIG. 4B
FIG. 4B

From FIG. 4A

A

312
Liquid pumped out of conduit

314
Gas released through gas release port
FIG. 5A

400 One or more valves opened on conduit

402 Conduit is submerged

404 Gas injected into the interior of the conduit

406 Gas injected into port of induction bell

408 Conduit positioned over plume

410 Appropriate valves opened

To FIG. 5B
FIG. 5B

From FIG. 5A

B

412

Liquid pumped out of conduit

414

Gas released through gas release port
UNIVERSAL SUBSEA OIL CONTAINMENT SYSTEM AND METHOD

RELATED APPLICATIONS

This utility application is a continuation-in-part application of co-pending U.S. patent application Ser. No. 13/162,666 entitled “Universal Subsea Oil Containment System and Method” filed on Jun. 17, 2011 under the name of George Carter which claims the benefit of U.S. Provisional Patent Application Ser. No. 61/358,697 filed Jun. 25, 2010 and is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

This invention relates to oil and gas systems. Specifically, and not by way of limitation, the present invention relates to a system and method in some scenarios, however, there are blowout scenarios were leaks develop outside the well casing, or leaks develop from the BOP or a damaged connector. Ideas have arisen to “drop” a containment device over the source of the spill, but containment domes have had limited success in shallow seawater and have never worked in deepwater environments. A dome-like design, with the open end attempting to seal to ocean floor sediment and debris, is inherently flawed. A new approach is needed to match the task of potential spill cleanup with the realities of deepwater and ultra-deepwater drilling.

Pending U.S. patent application Ser. No. 13/162,666 discloses a novel solution which can capture and contain oil and gas leaking from leaks originating from man-made structures at deep underwater depths. Specifically, U.S. patent application Ser. No. 13/162,666 discusses an apparatus and method which includes a conduit having an upper end and a lower end with an opening. The conduit is sized for the lower end to be positioned over a plume leaking from the man-made structure and the upper end to be substantially near or at the seawater surface. In addition, a containment tank is located in the upper portion of the interior of the conduit. The apparatus also includes a first tube for pumping liquid located within the containment tank out of the interior of the conduit, thereby creating a pressure differential between a pressure within the interior of the conduit and a pressure outside the conduit to induce an upward flow of fluids within the conduit. The interior pressure of the conduit is lower than the pressure outside the conduit. The apparatus also includes a second tube for releasing gas from the interior of the conduit. The apparatus also includes a port for introducing a suitable gas such as nitrogen into the interior of the conduit to displace water. In addition, the apparatus includes a plurality of valves for metering liquid and gas flow within the interior of the conduit. The conduit is positioned over the leaking man-made structure and liquid and gas flow upward from the leaking man-made structure through the interior of the conduit.

SUMMARY OF THE INVENTION

In one aspect, the present invention is directed to an apparatus for containing oil and gas leaking from an underwater man-made structure. The apparatus includes a conduit having an upper end and a lower end with an opening. The conduit is sized for the lower end to be positioned over a hydrocarbon plume leaking from the man-made structure and the upper end to be substantially near or at the seawater surface. In addition, a containment tank is located in the upper portion of the interior of the conduit. The apparatus also includes a first tube for pumping liquid located within the containment tank out of the interior of the conduit and a pressure differential between a pressure within the interior of the conduit and a pressure outside the conduit to induce an upward flow of fluids within the conduit. The interior pressure of the conduit is lower than the pressure outside the conduit. The apparatus also includes a second tube for releasing gas from the interior of the conduit. The apparatus also includes a port for introducing a suitable gas such as nitrogen into the interior of the conduit to displace water. In addition, the apparatus includes a plurality of valves for metering liquid and gas flow within the interior of the conduit. The conduit is positioned over the leaking man-made structure and liquid and gas flow upward from the leaking man-made structure through the interior of the conduit.

In another aspect, the present invention is directed to a method of containing oil and gas leaking from an underwater man-made structure. The method begins by closing one or more valves within an interior of a conduit. A suitable gas is injected into the interior of the conduit. Next, a conduit is positioned over a hydrocarbon plume leaking from the man-made structure. The conduit has an upper end located at or substantially near the seawater surface and a lower end having an opening leading to an interior of the conduit. Next, one or more of the values are opened to meter liquid and gas through the interior of the conduit. Liquid contained in the interior of the conduit is then pumped out from an upper portion of the
conduit to reduce an interior pressure of the conduit below a pressure outside the conduit to induce an upward flow of fluids. Gas is released through a gas release tube coupled to an interior of the conduit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a side view of a containment system in one embodiment of the present invention;
[0013] FIG. 2 is a side view of a containment system in another embodiment of the present invention;
[0014] FIG. 3 is an enlarged side view illustrating the induction bell; and
[0015] FIGS. 4A and 4B are flow charts illustrating the steps of containing and capturing oil and gas from a leaking structure using a conduit in a closed configuration; and
[0016] FIGS. 5A and 5B are flow charts illustrating the steps of containing and capturing oil and gas from a leaking structure using a conduit in an open configuration.

DESCRIPTION OF THE INVENTION

[0017] The present invention is a system and method of containing and capturing oil and gas leaking from an underwater man-made structure. FIG. 1 is a side view of a containment system 10 in one embodiment of the present invention. The containment system 10 includes a main conduit 12 having a first lower end 14 with an opening 16 and an opposite second upper end 18 with a containment tank 20. In one embodiment, the containment tank may be located below a seawater surface 22. In this embodiment, the containment tank may be coupled to a gas release tube 24 leading to the surface 22. The tube 24 may lead to an aperture 26 opened to the outside above-water environment 28 or to a man-made structure such as a ship (not shown). Flow control devices, such as fixed (e.g., Venturi) or variable (e.g., valves) may be used to control the flow of the gas exiting the tube. The containment tank may also include a second liquid ejection tube 30 having a pump (not shown) leading to the surface 22 and a capture vessel or other man-made structure (not shown). In an alternate embodiment, the containment tank may extend above the seawater surface 22.

[0018] In addition, the containment system 10 includes a base section 32 having the lower opening 16 coupled to the lower end 14 of the main conduit. The base section 32 may include an induction bell 34 having a diameter larger than the diameter of the main conduit 12. A dissociation zone 36 may be located in an interior of the conduit where gas hydrates are dissociated or melted. Gas hydrates may also form within interior the conduit in a gas-hydrate formation zone 84. The base section may be affixed to a sea floor 38 by any mechanism which allows the containment system to remain stationary over a plume (leak) originating from a man-made structure, such as a damaged blowout prevent (BOP) 40. In one embodiment, the base structure is attached to a plurality of base pylons 42 embedded into the sea floor 38. Preferably, the attachment mechanism includes at least three base pylons having cables 44 affixed to an attachment station 46. The cables may be lengthened or shortened to move the main conduit laterally or vertically in relation to a leak plume 50. In the preferred embodiment of the present invention, the main conduit may include floating collars (not shown) or other flotation devices to allow the main conduit to float underwater. The cables are used to attach the base structure and main conduit to the pylons. In other embodiments, the present invention may use other attachment devices (e.g., rigid arms) to retain the main conduit underwater and close to the leak. In the preferred embodiment of the present invention, the induction bell is positioned above the plume 50 with a vertical space 54. In addition, the open vertical space enables a space around the BOP 40 to be accessed by remote underwater devices such as Remotely Operated Vehicles (ROVs), which may be necessary when operators are attempting to repair the leaking structure while still capturing leaking oil and gas.

[0019] The interior 52 of the main conduit 12 may include a multi-phase flow zone for oil, gas-hydrates, natural gas, chemicals (such as monoethylene glycol (MEG)) and seawater. In the preferred embodiment of the present invention, the main conduit has a diameter A no larger than a standard 21 inch riser. This enables ease in constructing and assembling the containment system utilizing currently used parts and machinery. An upper section 60 of the main conduit may have a large diameter B in comparison to the main conduit to allow expansion from hydrate dissociation. In addition, in other embodiments, there may be many stages of increasingly greater diameters along the span of the conduit.

[0020] The conduit may be constructed of any material which may contain a liquid (e.g., liquid-tight). Furthermore, the cross-section of the conduit may be any shape. In addition, an interior wall of the conduit may be coated with an epoxy, an epoxy-like material or any other composite material to reduce the adhesive qualities of hydrates to the interior wall. Additionally, the conduit may include a double wall providing thermal insulation. By maintaining or increasing the temperature of the fluids within the conduit, hydrate formation is reduced. In one embodiment, the conduit is sized in the conduit's length to enable the conduit to be positioned over the plume 50 and still reach near (relative to the depth of the seawater and length of the conduit) or at the seawater surface. The conduit may be constructed in sections to accommodate varying depths from the surface to a wellhead. The conduit diameter is large enough to prevent clogging from gas-hydrates and allow for dissociation of hydrates and expansion of natural gas.

[0021] The induction bell 34 may include ports for injecting MEG, methanol, anti-agglomerant, or other chemicals into the interior of the conduit. The expanding natural gas and fluid rises up through the conduit into the containment tank 20. A liquid level 64 in the containment tank is adjustable depending on the rate the fluid that is pumped out of the liquid ejection tube 30.

[0022] A pump (not shown) may be used to pump out the oil and fluid within the containment tank 20 through the liquid ejection tube 30 to a tanker or other storage facility located above seawater. This fluid may be stored in a tanker (not shown) through an exit point 70. The fluid is pumped out to maintain the liquid level 64 below the seawater surface 22. This provides a pressure differential 62 between the interior of the conduit and outside seawater pressure which induces an upward flow of fluids (i.e., seawater, oil, and gas). Specifically, by pumping out the fluid, the liquid level 64 inside the conduit, in the containment tank, is maintained below the seawater surface, thereby keeping pressure in an interior 80 lower than outside 82 (underwater) at any given depth of the conduit. It should be understood that a conduit may be any device having a passageway or channel which can contain, funnel or channel the escaping gas and oil from the wellhead to the surface. Although the term conduit is used, the present invention is not limited to tubular or pipe-like devices and...
may be configured in any size and shape. In addition, the tubes referred to in the liquid ejection tube and gas release tube may be any conduit or device allowing the transfer of oil and gas out of the interior of the conduit.

[0023] FIG. 2 is a side view of a containment system 100 in another embodiment of the present invention. The containment system 100 of FIG. 2 may be used in the same manner as the containment system 10 and may contain various modifications from the system of FIG. 1. The containment system 100 may include a main conduit 112 having a first lower end 114 with an opening 116 and an opposite second upper end 118 with a containment tank 120. The containment tank 120 may include a Gas/Liquid Cylindrical Cyclone (GLCC) commonly used in the oil and gas industry which provides optimum gas-liquid separation performance. In one embodiment, the containment tank may be located below a seawater surface 22. In this embodiment, the containment tank may be coupled to a gas release tube 124 leading to the surface 22. The tube 124 may lead to an aperture 126 opened to the outside above-water environment 28 or to a man-made structure such as a ship (not shown). The containment tank may also include a second liquid ejection tube 130 having a pump (not shown) leading to the surface 22 and a capture vessel or other man-made structure (not shown). In an alternate embodiment, the containment tank may extend above the seawater surface 22.

[0024] In addition, the containment system 100 includes a base section 132 having the lower opening 116 coupled to the lower end 114 of the main conduit. The base section 132 may include an induction bell 134 having a diameter larger than the diameter of the main conduit 112. Gas-hydrates may form within the interior of the conduit in a gas-hydrate formation zone 184. The base section may be affixed to a sea floor 38 by any mechanism which allows the containment system to remain stationary over a plume (leak) originating from a man-made structure, such as a damaged blowout prevent (BOP) 40. In one embodiment, the base structure is attached to a plurality of base pylons 42 embedded into the sea floor 38. Preferably, the attachment mechanism includes at least three base pylons having cables 44 affixed to an attachment station 46. The cables may be lengthened or shortened to move the main conduit laterally or vertically in relation to a leak plume 50. The plume, BOP and base components are not shown in FIG. 2, although the containment system 100 may or may not include such components as depicted in FIG. 1. The main conduit may include floatation collars (not shown) or other floatation devices to allow the main conduit to float underwater. The cables are used to attach the base structure and main conduit to the pylons. In other embodiments, the present invention may use other attachment devices (e.g., rigid arms) to retain the main conduit underwater and close to the leak.

[0025] The interior 152 of the main conduit 112 may include a multi-phase flow zone for oil, gas-hydrates, natural gas, and seawater. The percentage of seawater is controlled by adjusting the pressure differential. In one embodiment of the present invention, the main conduit has a diameter A no larger than a standard 21 inch riser. This enables ease in constructing and assembling the containment system utilizing currently used parts and machinery. In one embodiment of the present invention, there may be many stages of increasingly greater diameters along the span of the conduit.

[0026] The conduit may be constructed of any material which may contain a liquid (e.g., liquid-tight). Furthermore, the cross-section of the conduit may be any shape. In addition, an interior wall of the conduit may be coated with an epoxy, an epoxy-like material or any other composite material to reduce the adhesive qualities of hydrates to the interior wall. In one embodiment, the conduit is sized in the conduit’s length to enable the conduit to be positioned over the plume 50 and still reach near (relative to the depth of the seawater and length of the conduit) or at the seawater surface. The conduit may be constructed in sections to accommodate varying depths from the surface to a wellhead. The conduit diameter is large enough to prevent clogging from gas-hydrates and allow for dissociation of hydrates and expansion of natural gas as the gas-hydrates rise toward the surface where the gas is separated from the liquid.

[0027] The induction bell 134 may include ports for injecting anti-agglomerant, or other chemicals into the interior of the conduit. The expanding natural gas and liquid rises up through the conduit into the containment tank 120. A liquid level 164 in the containment tank is adjustable depending on the rate the fluid is pumped out of the liquid ejection tube 130.

[0028] A pump (not shown) may be used to pump out the contained oil and liquids within the containment tank 120 through the liquid ejection tube 130 to a tank or other storage facility located above sea level. This liquid may be stored in a tank (not shown) through an exit point 170. The liquid is pumped out to maintain the liquid level 164 below the seawater surface 22. This provides a pressure differential between the interior of the conduit and outside seawater pressure which induces an upward flow of fluids (i.e., seawater, oil, and gas). Specifically, by pumping out the liquid, the liquid level 164 inside the conduit, in the containment tank, is maintained below the seawater surface, thereby keeping pressure in an interior 180 lower than outside 82 (underwater) at any given depth of the conduit. It should be understood that a conduit may be any device having a passageway or channel which can contain, funnel or channel the escaping gas and oil from the wellhead to the surface. Although the term conduit is used, the present invention is not limited to tubular or pipeline devices and may be configured in any size and shape. In addition, the tubes referred to in the liquid ejection tube and gas release tube may be any conduit or device allowing the transfer of oil and gas out of the interior of the conduit.

[0029] Flow control devices, such as fixed (e.g., Venturi) or variable (e.g., valves) may be used to control the flow of the gas exiting the tube. As depicted in FIG. 2, the containment system 100 includes a lower valve 190 controlling the opening 116, an upper valve 192 at a lower end of the containment tank 120, a valve 194 in the liquid ejection tube 130 and a valve 196 in the gas release tube 124. It should be understood that the valves may be located anywhere and still remain in the scope of the present invention. The valves are also utilized to contain an injection of a gas, such as nitrogen into the interior of the conduit. As discussed, the conduit may include several sections. Each section may include an upper and lower valve located at each end of the section. In addition, the conduit may include one or more gas ports 200. A gas port may be located in each section of a staged conduit. Additionally, the induction bell 134 may include a gas port 202.

[0030] FIG. 3 is an enlarged side view illustrating the induction bell 134. The induction bell may include insulation 210. Additionally, the induction bell may include a cover shell 212 having a heated cavity 214. A gas port 216 leading to the cavity 214 may allow the introduction of MEG, methanol, or other chemical into the cavity. A discharge slot 220 may be utilized for discharging the MEG, methanol, or other chemical from the cavity.
With reference to FIGS. 1-3, the operation of the containment system 100 will now be explained. In a first embodiment of the present invention, the valves 190 and 192 are closed to the conduit 112 or a specific section of the conduit. This first embodiment is also known as the "dry" embodiment. The conduit or section of conduit is submerged into the seawater. As the conduit descends, a gas such as nitrogen is introduced through the port 200 into the interior 152 of the conduit. The introduction of the gas provides an internal pressure to the conduit, thereby enhancing the structural integrity of the conduit and preventing pressure from the surrounding seawater from crushing the conduit. In most cases where the depth of the lowest end of the conduit is less than approximately 8000 feet, the use of nitrogen is acceptable. In particular, when utilizing nitrogen, hydrates of nitrogen do not form where pressure is approximately 8000 feet of seawater or less. The conduit may still be lowered below 8000 feet seawater pressure with the internal pressure of the conduit remaining at approximately 8000 feet of seawater, which is of a sufficient outward pressure to retain the structural integrity of the conduit and counteract the inward pressure from the seawater on the conduit. If the conduit is constructed in sections, each section may include upper and lower valves to prevent passage of seawater into the section's interior. Additionally, each section may include a port to introduce the gas (e.g., nitrogen) into the interior of the section. The sections are added to the conduit as needed to provide a length of the conduit as necessary for the required depth to the plume.

The conduit is eventually positioned near the plume 50 from a leaking wellhead, man-made structure, BOP 40 or where the leak emanates (e.g., sea-floor). The conduit may be moved laterally to position the opening 116 of the conduit directly over the plume 50. The appropriate valves are then opened as necessary to meter a portion of the leaking hydrocarbons (fluids, which includes gas and liquid) through the interior of the conduit. After the flow of the fluids progresses upward, the valves may be configured as necessary to allow passage of a majority, or all of the leaking fluid through the interior of the conduit. Furthermore, after startup of the flow of fluids in the conduit, the introduction of gas (nitrogen) is discontinued into the conduit. As gas and oil (hydrocarbons) escape from the wellhead, the oil and gas travels up the conduit 112. The liquid (e.g., oil and seawater) is pumped out of the conduit to a storage area, such as a tanker through the liquid ejection tube 130. Furthermore, the natural gas contained in the containment tank 120 may be released through the gas release tube 124, where the natural gas may be contained or flared. The liquid level 164 is maintained below the seawater surface 22. The escaping oil and gas emitted from the wellhead rise through the conduit where the liquid is pumped out the liquid ejection tube 130 and gas is released through the release tube respectively. The startup of the flow of fluids through the conduit provides for minimal flow of seawater through the interior of the conduit, thereby reducing the formation of hydrates in the interior of the conduit.

In a second embodiment of the present invention, the conduit is submerged in an open configuration where the lower valve 190 is opened and the upper valve 192 is closed prior to entering the seawater. This second embodiment is also known as the "wet" embodiment. The nitrogen or other suitable gas may then be introduced into the interior through the port 200 when the conduit or section is submerged. The nitrogen gas displaces the seawater in the interior of the conduit out through the valve 190. After injecting the nitrogen into the interior of the conduit, the conduit is eventually positioned near the plume 50 from a leaking wellhead, man-made structure, BOP 40 or where the leak emanates (e.g., sea-floor). The conduit may be moved laterally to position the opening 116 of the conduit directly over the plume 50. In a similar manner as the dry embodiment, the appropriate valves are then opened as necessary to meter a portion of the leaking hydrocarbons (fluid, which includes gas and liquid) through the interior of the conduit. After the flow of the fluids progresses upward, the valves may be configured as necessary to allow passage of a majority or all of the leaking fluid through the interior of the conduit. Furthermore, after startup of the flow of fluids in the conduit, the introduction of gas (nitrogen) is discontinued into the conduit. As gas and oil (hydrocarbons) escape from the wellhead, the oil and gas travel up the conduit 112. The liquid (e.g., oil and seawater) is pumped out of the conduit to a storage area, such as a tanker through the liquid ejection tube 130. Furthermore, the natural gas contained in the containment tank 120 may be released through the gas release tube 124, where the natural gas may be contained or flared. The liquid level 164 is maintained below the seawater surface 22. The escaping oil and gas emitted from the wellhead rise through the conduit where the liquid is pumped out the liquid ejection tube 130 and gas is released through the release tube respectively. The startup of the flow of fluids through the conduit, as in the other dry embodiment discussed above, provides for minimal flow of seawater and mostly hydrocarbons, thereby reducing the formation of hydrates in the interior of the conduit.

For both embodiments described above, as the conduit is submerged, the induction bell enters the seawater open to the seawater. Once the induction bell 134 is at the desired depth of 8000 feet or less, nitrogen is injected through the port 202 into the interior of the induction bell to displace the seawater out of the interior of the induction bell. For depths greater than 8000 feet, helium may be substituted for nitrogen. In addition, MEG, methanol, or other chemical may be optionally injected into the cavity 214 through the port 216 and discharged through the discharge slot 220. The use of MEG, methanol, or other chemical also reduces the occurrence of hydrates in the induction bell.

FIGS. 4A and 4B illustrate flow charts illustrating the steps of containing and capturing oil and gas from a leaking structure by submerging a closed conduit according to the teachings of the present invention. FIGS. 4A and 4B relate to the dry embodiment discussed above. With reference to FIGS. 1-4, the method will now be explained. The conduit may be constructed in sections to provide a length allowing the conduit to span from the bottom of the ocean floor where the wellhead is located to at or near the seawater surface 22. Prior to beginning the method, the conduit is assembled, preferably one section at a time and placed underwater. The method begins with step 300, where the valves 190 and 192 are closed to the conduit 112, or a section of the conduit.

Next, in step 302, the conduit or section of conduit is submerged into the seawater to the desired depth or a maximum of approximately 8000 feet. As the conduit descends into the seawater, suitable gas such as nitrogen is introduced into the interior of the conduit in step 304. The introduction of the suitable gas provides an internal pressure to the conduit, thereby enhancing the structural integrity of the conduit and preventing pressure from the surrounding seawater from crushing the conduit. In most cases where the depth of the conduit is less than 8000 feet, the use of nitro-
gen is acceptable. In particular, nitrogen hydrates do not form for seawater pressure of approximately 8000 feet or less. The conduit may still be lowered below 8000 feet seawater pressure with the internal pressure of the conduit remaining at approximately 8000 feet, which is of a sufficient outward pressure upon the conduit to retain the structural integrity of the conduit and counteract the inward pressure from the seawater on the conduit. If the conduit is constructed in sections, each section may include upper and lower valves to prevent passage of seawater into the section’s interior. Additionally, each section may include a port to introduce the gas (e.g., nitrogen) into the interior of the section. The sections are added to the conduit as needed to provide a length of the conduit as necessary for the required depth to the plume.

As the conduit is submerged, the induction bell enters the seawater open to the seawater. In step 306, once the induction bell 134 is at the desired depth 8000 feet or less, nitrogen is optionally injected through the port 202 into the interior of the induction bell to displace the seawater out of the interior of the induction bell. For depths greater than 8000 feet, helium (which does not form hydrates below 8000 feet) may be substituted for nitrogen. In addition, MEG, methanol, or other chemical may be optionally injected into the cavity 214 through the port 216 and discharged through the discharge slot 220. The use of MEG, methanol or other chemical also reduces the occurrence of hydrates in the induction bell.

In step 308, the conduit is positioned over the plume 50 from a leaking wellhead, man-made structure, BOP 40 or where the leak emanates (e.g., seafloor). Next, in step 310, the appropriate valves are then opened as necessary to meter a portion of the leaking hydrocarbons (fluids, which includes gas and liquid) and some seawater through the conduit. As the upward flow of the fluids progress, the valves may be configured as necessary to allow passage of a majority or all of the leaking hydrocarbons through the interior of the conduit. Furthermore, after startup of the flow of fluids in the conduit, the introduction of gas (such as nitrogen) may be discontinued into the conduit. As gas and oil (hydrocarbons) escape from the wellhead, the oil and gas travel up the conduit 112. In step 312, the liquid is pumped out of the conduit to a storage area, such as a tanker through the liquid ejection tube 130. In step 314, the natural gas contained in the containment tank 120 may be released through the gas release tube 124 where the natural gas may be contained or flared. The startup of the flow of fluids through the conduit provides for minimal flow of seawater and mostly hydrocarbons, thereby reducing the formation of hydrates in the interior of the conduit.

FGS. 5A and 5B are flow charts illustrating the steps of containing and capturing oil and gas from a leaking structure by submerging in an open conduit according to the teachings of the present invention. Figs. 1-3, and 5, the method will now be explained. The method begins with step 400 where the lower valve 190 is opened. Next, in step 402, the conduit or section of conduit is submerged into the seawater to the desired depth or a maximum of approximately 8000 feet. In step 404, nitrogen is then injected into the interior of the conduit through port 200 to displace the seawater from the interior of the conduit. The nitrogen gas displaces the seawater in the interior of the conduit out through the valve 190. Valve 190 is then closed. If the leaking structure is at a depth greater than approximately 8000 feet, the conduit may continue to be lowered to the desired depth. As the conduit is submerged, the induction bell enters the seawater open to the seawater. In step 406, once the induction bell 134 is at the desired depth 8000 feet or less, nitrogen is optionally injected through the part 202 into the interior of the induction bell to displace the seawater out of the interior of the induction bell. For depths greater than approximately 8000 feet, helium (which does not form hydrates below 8000 feet) may be substituted for nitrogen. In addition, MEG, methanol, other chemical or other gas/liquid may be optionally injected into the cavity 214 through the port 216 and discharged through the discharge slot 220. The use of MEG, methanol, or other chemical also reduces the occurrence of hydrates in the induction bell.

In step 408, the conduit is positioned over the plume 50 from a leaking wellhead, man-made structure, BOP 40 or where the leak emanates (e.g., seafloor). Next, in step 410, the appropriate valves are then opened as necessary to meter a portion of the leaking hydrocarbons (i.e., fluids, which includes gas and liquid) through the interior of the conduit. As the upward flow of the fluids progress, the valves may be configured as necessary to allow passage of a majority or all of the leaking hydrocarbons through the interior of the conduit. Furthermore, after startup of the flow of fluids in the conduit, the introduction of gas (nitrogen) may be discontinued into the conduit. As gas and oil (hydrocarbons) escape from the wellhead, the oil and gas travel up the conduit 112. In step 412, the liquid is pumped out of the conduit to a storage area, such as a tanker through the liquid ejection tube 130. In step 414, the natural gas contained in the containment tank 120 is released through the gas release tube 124 where the natural gas may be contained or flared. The startup of the flow of fluids through the conduit provides for minimal flow of seawater and mostly hydrocarbons, thereby reducing the formation of hydrates in the interior of the conduit.

The present invention utilizes a negative pressure differential which causes the fluid to flow upward away from the leaking structure. The oil and gas may be drawn from the interior of the conduit and stored in areas designated by the operators. The present invention introduces a suitable gas into the interior of the conduit to eliminate or displace seawater from the interior of the conduit during startup. Additionally, the introduction of a suitable gas into the interior of the conduit provides an internal pressure to counteract the external pressure from the surrounding seawater.

While the present invention is described herein with reference to illustrative embodiments for particular applications, it should be understood that the invention is not limited thereto. Those having ordinary skill in the art and access to the teachings provided herein will recognize additional modifications, applications, and embodiments within the scope thereof and additional fields in which the present invention would be of significant utility.

Thus, the present invention has been described herein with reference to a particular embodiment for a particular application. Those having ordinary skill in the art and access to the present teachings will recognize additional modifications, applications, and embodiments within the scope thereof.

It is therefore intended by the appended claims to cover any and all such applications, modifications and embodiments within the scope of the present invention.

1. A system of containing oil and gas leaking from an underwater man-made structure, the system comprising:

   a conduit positioned over a plume leaking from the man-made structure;
the conduit having an upper end located at or substantially near a seawater surface and a lower end positioned over the leaking man-made structure, the lower end having an opening leading to an interior of the conduit;
means for creating a pressure differential between a pressure within the interior of the conduit and a pressure outside the conduit to induce an upward flow of fluids within the interior of the conduit, the interior pressure of the conduit being below the pressure outside the conduit;
means for expelling liquid from the interior of the conduit;
means for releasing gas from the interior of the conduit;
means for introducing a suitable gas into the interior of the conduit for displacing seawater from the interior of the conduit;
a plurality of valves for metering liquid and gas flow within the interior of the conduit;
whereby liquid and gas flow upward from the leaking man-made structure through the interior of the conduit and are removed from the interior of the conduit.
2. The system according to claim 1 wherein the upper end of the conduit includes a containment tank.
3. The system according to claim 2 wherein the containment tank includes a Gas/Liquid Cylindrical Cyclone (GLCC).
4. The system according to claim 3 wherein the containment tank includes a port for injecting monoethylene glycol (MEG), methanol or other chemical into the interior of the containment tank.
5. The system according to claim 2 wherein the means for creating a pressure differential includes means for pumping any liquid located in the containment tank out of the containment tank.
6. The system according to claim 2 wherein the means for releasing gas is a gas release tube coupled to the containment tank.
7. The system according to claim 6 wherein the gas release tube releases gas above the seawater surface.
8. The system according to claim 2 wherein the means for expelling liquid from the interior of the conduit includes:
a liquid ejection tube coupled to the containment tank for expelling the liquid from the interior of the conduit; and
a pump for pumping the liquid from the interior of the conduit.
9. The system according to claim 1 wherein the plurality of valves includes an upper valve located near the upper end of the conduit and a lower valve located at the lower end of the conduit.
10. The system according to claim 1 wherein the means for introducing a suitable gas into the interior of the conduit is a port for injecting the suitable gas from outside the conduit into the interior of the conduit.
11. The system according to claim 1 wherein the conduit is constructed of two or more sections coupled together.
12. The system according to claim 11 wherein each section includes at least one valve for metering liquid and gas within the interior of the conduit.
13. The system according to claim 1 wherein the lower end includes an induction bell for gathering leaking hydrocarbons from the man-made structure.
14. The system according to claim 13 wherein the induction bell includes a port for injecting a suitable gas into the interior of the conduit.
15. The system according to claim 1 wherein the conduit includes a double wall providing thermal insulation to the conduit.
16. A method of containing oil and gas leaking from an underwater man-made structure, the method comprising the steps of:
closing one or more valves within an interior of a conduit;
injecting a suitable gas into the interior of the conduit;
positioning a conduit over a plume leaking from the man-made structure, the conduit having an upper end located at or substantially near the seawater surface and a lower end having an opening leading to an interior of the conduit;
opening one or more valves to meter liquid and gas through the interior of the conduit;
pumping liquid from an upper portion of the interior of the conduit to reduce an interior pressure of the conduit below a pressure outside the conduit to induce an upward flow of fluids within the interior of the conduit; and
expelling gas located within the interior of the conduit through a gas release tube coupled to an interior of the conduit.
17. The method according to claim 16 wherein:
the step of closing one or more valves includes closing all valves for configuring the conduit in a closed configuration; and
the step of injecting a suitable gas into the interior of the conduit includes injecting a gas as the conduit is submerged into the seawater.
18. The method according to claim 15 wherein:
the step of closing one or more valves includes leaving at least one valve open for configuring the conduit in an open configuration; and
the step of injecting a suitable gas into the interior of the conduit includes injecting a gas after the conduit is submerged to displace the seawater from the interior of the conduit.
19. The method according to claim 16 wherein the upper portion of the conduit includes a containment tank and the step of pumping liquid from an upper portion includes pumping liquid located within the containment tank out of the conduit.
20. The method according to claim 16 wherein the step of injecting a suitable gas includes injecting nitrogen into the interior of the conduit.
21. The method according to claim 16 further comprising the step of injecting a suitable gas into an interior of an induction bell, the induction bell being located at the lower end of the conduit.
22. The method according to claim 21 further comprising the step of injecting monoethylene glycol (MEG), methanol, other chemical into a cavity surrounding the induction bell.
23. An apparatus for containing oil and gas leaking from an underwater man-made structure, the apparatus comprising:
a conduit having an upper end and a lower end with an opening, the conduit being sized for the lower end to be positioned over a plume leaking from the man-made structure and the upper end to be substantially near or at a seawater surface;
a containment tank located in the upper portion of the interior of the conduit;
a first tube for pumping liquid located within the containment tank out of the interior of the conduit, thereby
creating a pressure differential between a pressure within the interior of the conduit and a pressure outside the conduit to induce an upward flow of fluids, within the interior of the conduit, the interior pressure of the conduit being below the pressure outside the conduit; a second tube for releasing gas from the interior of the conduit; a port for introducing a suitable gas into the interior of the conduit for displacing seawater from the interior of the conduit; a plurality of valves for metering liquid and gas flow within the interior of the conduit; whereby the conduit is positioned over the leaking man-made structure and liquid and gas flow upward from the leaking man-made structure through the interior of the conduit.

24. The system according to claim 23 wherein: the lower end includes an induction bell for gathering leaking hydrocarbons from the man-made structure; and the induction bell includes a port for injecting a suitable gas into the interior of the conduit.

25. The system according to claim 23 wherein the conduit includes a double wall providing thermal insulation to the conduit.

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