(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 January 2014 (03.01.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/000760 A1

(51) International Patent Classification:
E21B 17/01 (2006.01) *E21B 47/10* (2012.01)
E21B 43/01 (2006.01) *F16L 11/08* (2006.01)

(21) International Application Number:
PCT/EP2012/062233

(22) International Filing Date:
25 June 2012 (25.06.2012)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **STATOIL PETROLEUM AS** [NO/NO]; N-4035 Stavanger (NO).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **LØSETH, Svein** [NO/NO]; Tonstadgrenda 9, N-7091 Tiller (NO).

(74) Agent: **ZACCO NORWAY AS**; P.O. Box 2003 Vika, N-0125 Oslo (NO).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: ARRANGEMENT FOR VENTING A RISER ANNULUS

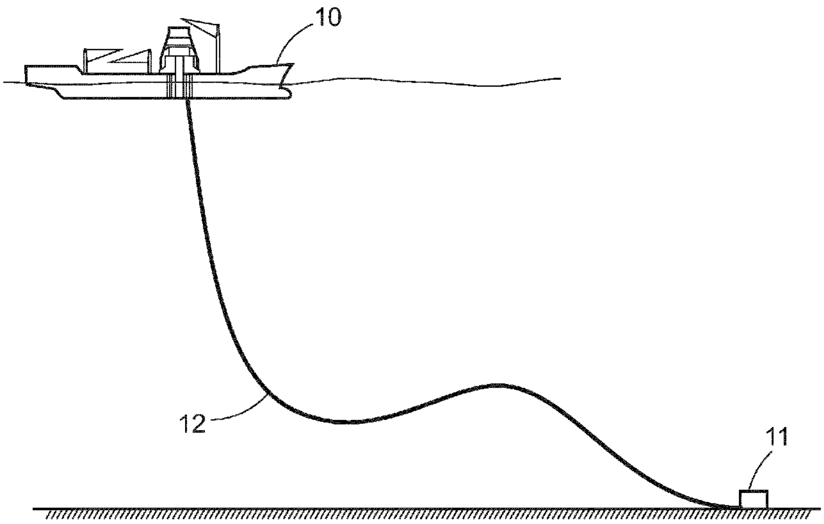

Fig.1

(57) **Abstract**: A riser venting arrangement in a subsea riser (12) used for conveying hydrocarbons, includes an inner sheath (32) and an outer sheath (35) separated by an annular space. The venting arrangement further comprises a permeate recovery device, such as a vacuum pump (20) for recovering permeate passing through the sheaths into the annular space by creating a sub-atmospheric pressure in the annular space, which permeate recovery device is connected to the riser adjacent an upper region thereof and communicates with a permeate recovery line (12); a permeate storage tank (22) connected to the recovery line; and a one-way valve (23) in the recovery line between the permeate recovery device and the storage tank, preventing flow from the permeate recovery line into the annular space.

WO 2014/000760 A1

ARRANGEMENT FOR VENTING A RISER ANNULUS

TECHNICAL FIELD

The present invention relates to method and an arrangement for venting an annular space between two sheaths in a riser for conveying hydrocarbons.

BACKGROUND ART

Conduits to transfer materials from the seafloor to production and drilling facilities at the surface, as well as from the facility to the seafloor, are commonly termed risers. Risers are a type of pipe developed for this type of vertical transportation. Risers can serve as production or import/export means and are the connection between the subsea field developments and production and drilling facilities. Similar to pipelines or flow lines, risers transport produced hydrocarbons, as well as production materials, such as injection fluids, control fluids and gas lift. Usually insulated to withstand seafloor temperatures, risers can be either rigid or flexible

A flexible riser is a hybrid that can accommodate a number of different situations. Flexible risers can withstand both vertical and horizontal movement, making them ideal for use with floating facilities. This flexible pipe was originally used to connect production equipment aboard a floating facility to production and export risers, but now it is found as a primary riser solution as well. There are a number of configurations for flexible risers, including the steep S and lazy S that utilize anchored buoyancy modules, as well as the steep wave and lazy wave that incorporates buoyancy modules.

In general, a flexible riser comprises a central steel carcass covered by a pressure sheath that provides hydraulic integrity. Numerous layers of flexible armour surround the pressure sheath, or pressure vault, to provide tensile- and hoop-stress strength. The armour layers are usually separated by cushioning layers of composite or thermoplastic material to prevent them from rubbing against one another. The number and size of armour layers is a function of the pressure and tensile strength specifications imposed by the particular application for which the riser is designed. A final thermoplastic outer sheath provides protection towards the external environment. The layers between the pressure sheath and the outer protection sheath, partly filled with steel armour, tapes is normally called the riser annulus. Special riser structures may have two or more annuli.

In the case of flexible risers, gas and vapour diffusion can occur through the riser pressure sheath into the riser annulus, exposing the riser armour to condensation vapour, hydrocarbons and corrosive gases like CO_2 and H_2S, also termed permeate. This will eventually cause corrosion and corrosion fatigue of the riser armour, thus reducing its service life. Permeate in gaseous form can migrate upwards and slowly pressures up the riser's annulus by typically 0.5-1 bar above atmospheric. Then, a solenoid valve opens, dumping the annulus gas through a gas flow meter into the flare line. However, this migration is relatively slow and not all permeate can be removed this way.

GB 2481765 describes a known method for removing liquid and gas from the annulus of a flexible riser. In the vertical orientation, liquid permeate will condense in the annulus and fall to the base of the riser under gravity, where a column of liquid would quickly develop in the annulus. A reliable venting system is required for the removal of the condensed permeate which collects at the base of the riser. This is necessary to avoid the situation where the liner experiences external overpressure and possible collapse in the event that there is a loss of internal pressure in the bore. In this document, a storage tank is connected to a lowermost portion of the riser, allowing liquid to drain from the riser annulus. Liquid and gas can then be pumped to the surface via separate recovery lines for gaseous and liquid permeate. A problem with this solution is that it requires multiple conduits between the sea floor and the surface, which causes difficulties when the riser needs to be disconnected at the sea floor or at the surface. Even though the condensed fluids are drained with this arrangement, armour threads will still be wetted and the partial pressures corrosive gases like H_2S and CO_2 may still be at a level high enough to cause corrosion fatigue.

Hence, there is a need for an arrangement that avoids the above problems. The object of the invention is to provide an improved riser venting and drying arrangement that will provide sufficient venting and drying of the riser annulus and to reduce the partial pressure of the corrosive gases to avoid annulus corrosion fatigue and corrosion problems.

DISCLOSURE OF INVENTION

The above problems are solved by an arrangement and a method as described in the attached claims.

In the subsequent text, the term "permeate" is defined as covering any media desirable to be vented from a subsea riser. Non-exhaustive examples of such media are carbon dioxide (CO_2), hydrogen sulphide (H_2S) and water (H_2O).

The invention relates to a riser venting arrangement in a subsea riser used for conveying hydrocarbons, the riser includes an inner sheath and an outer sheath separated by an annular space containing steel armouring. The inner sheath is often termed pressure sheath, and the outer sheath is an outer protective sheath. The venting arrangement further comprises a permeate recovery device for recovering permeate passing through the inner sheath into the annular space by creating a sub-atmospheric pressure in the annular space, which permeate recovery device is connected to the riser. The permeate recovery device further communicates with a permeate recovery line normally connected to a venting line.

The permeate recovery device is preferably connected adjacent an upper region of the riser, but can also be connected adjacent a lower end of the riser or at any suitable position between the upper end and the lower end.

A valve, such as a one-way valve, is often included in the system, preventing flow from the permeate recovery line back into the annular space. Alternatively, a suitable controllable valve can be used. The valve is located downstream of the permeate recovery device.

At a low point in the venting system there is typically placed a sample bottle, or a suitable storage tank, for collecting condensing vapour. Such a storage tank is preferably, but not necessarily, located downstream of the valve.

The permeate recovery device is preferably, but not necessarily, a vacuum pump. In order to achieve the desired sub-atmospheric pressure any suitable means or source of low pressure can be used.

The permeate recovery device is arranged to recover permeate in gaseous form from the annular space. As the pressure in the annular space is reduced, the partial gas pressure of the gases and liquids in the annular space is reduced, lowering the boiling point of said media. According to one example, the permeate recovery device is arranged to maintain a predetermined sub-atmospheric pressure in the annular space, which pressure is sufficient to prevent condensation of water, and other substances therein and reduce the partial pressures of corrosive and harming gases like CO_2 and H_2S. For instance, CO_2, H_2S will always be is gas form at the temperatures and pressures occurring in the riser annulus.

A pressure sensor can be arranged to monitor the sub-atmospheric pressure in the annular space and to control operation of the permeate recovery device. The pressure sensor can be connected to an electronic control unit that controls the operation of the permeate recovery device, so that a predetermined sub-atmospheric pressure can be maintained in the annular space. The pressure sensor is arranged to monitor pressure variations in the annular space, indicating a leakage in the riser.

The riser venting arrangement is preferably, but not necessarily, intended for a flexible riser but can also be used for flexible jumpers and flow lines both topside and subsea. The particular design of the layers radially inside, in and radially outside the annulus is not relevant to the invention as such.

The riser venting arrangement according to the invention can also be provided with a flare connected to the sample bottle, or a storage tank, wherein excess gaseous permeate can be vented from the sample bottle to the flare.

The invention further relates to a riser venting method used to vent a subsea riser for conveying hydrocarbons. As described above, the riser includes two sheaths separated by an annular space. The method is preferably adapted for use with the arrangement described above.

The method according to the invention comprises the steps of

- operating a permeate recovery device creating a sub-atmospheric pressure in the annular space, and
- drawing vapour from the annular space through the permeate recovery device to a vent line.

The invention further involves drawing vapour from the annular space past a valve, such as a one-way valve, located downstream of the permeate recovery device.

Vapour drawn from the annular space passes into a permeate storage tank downstream of the permeate recovery device. When a valve is used, the permeate storage tank is downstream of the one-way valve.

The riser venting method involves creating and subsequently maintaining a predetermined sub-atmospheric pressure in the annular space, which pressure is sufficient to prevent condensation of permeate, such as water therein. The vapour can be drawn into a storage tank such as a sample bottle.

The riser venting method further involves monitoring the sub-atmospheric pressure and controlling operation of the permeate recovery device. Pressure variations in the annular space can be monitored, as variations can indicate a leakage in the riser. For instance, a rate of pressure build-up that exceeds a predetermined limit during a period of non-operation of the recovery device indicates a leakage in the inner sheath or the outer sheath of the riser. By sampling the permeate recovered from the annular space and determining its chemical composition, the source of the leakage can be determined. For instance, if the permeate comprises an increased hydrocarbon content, then the leak is located in the inner sheath. Similarly, if the permeate comprises an increased water content, then the leak is located in the outer sheath.

The system will also typically include a flow meter for detection of significant increase of fluid flow as this will indicate a leakage in the sheaths comprising the annulus.

The system can also be used for automatically or manual operated measuring of the annulus volume. This can be done by stopping the pump, typically once a year or more frequent if found appropriate, and let the annulus pressure increase to typically atmospheric pressure. When starting the pump again, the evacuated gas volume and the pressure decrease in the annulus can be measured and the annulus volume can be calculated by the gas equation.

BRIEF DESCRIPTION OF DRAWINGS

In the following text, the invention will be described in detail with reference to the attached drawings. These schematic drawings are used for illustration only and do not in any way limit the scope of the invention. In the drawings:

Figure 1 shows a riser extending from the sea floor to a production vessel;

Figure 2 shows a schematic diagram of a riser with a venting arrangement according to the invention; and

Figure 3 shows a schematic illustration of the layers making up a flexible riser.

EMBODIMENTS OF THE INVENTION

Figure 1 shows a flexible riser 12 extending from the sea floor to a production vessel 10. Oil is produced by subsea wells via a manifold, which passes through rigid flow lines and then flexible risers into a floating production, storage and offloading system. The vessel shown in this figure is a ship, but the arrangement is applicable on any type of floating, semi-submersible of permanent production platform. Flexible risers can withstand both vertical and horizontal movement, making them ideal for use with floating facilities. The flexible pipe was originally used to connect production equipment aboard a floating facility to production and export risers, but can be used as a primary riser solution as well. There are a number of configurations for flexible risers, including the steep S and lazy S that utilize anchored buoyancy modules, as well as the steep wave and lazy wave that incorporates buoyancy modules. Figure 1 indicates both a lazy wave and a steep wave arrangement of the flexible riser.

As shown in Figure 1, the riser assembly comprises a riser base11 located on the seabed, connected to the lower end of the flexible riser 12. The flexible riser 12 comprises a carcass, a pressure barrier, pressure and tensile armours, and an outer protective sheath (not shown).

Figure 2 shows a schematic diagram of a riser with a venting arrangement according to the invention. Using the numbering from Figure 1, a riser 12 extends from a manifold (see Figure 1) located on the seabed to a vessel on the surface.

The venting arrangement further comprises a permeate recovery device 20 for recovering permeate passing through the sheaths into the annular space by creating a sub-atmospheric pressure in the annular space, which permeate recovery device 20 is connected to the riser 12 adjacent an upper region thereof. In this example, the permeate recovery device is a vacuum pump 20. The vacuum pump 20 communicates with a permeate recovery line 21 and a permeate storage tank 22 connected to the recovery line 21 downstream of the vacuum pump 20. A one-way valve 23 is provided in the recovery line 21 between the vacuum pump 20 and the storage tank 22. The one-way valve 23 prevents flow from the permeate recovery line 21 back into the annular space.

The permeate recovery device is preferably, but not necessarily, a vacuum pump. In order to achieve the desired sub-atmospheric pressure any suitable means or source of low pressure can be used.

The vacuum pump 20 is arranged to recover permeate in gaseous form from the annular space. As the pressure in the annular space is reduced, the partial gas pressure of the gases and liquids in the annular space is reduced, lowering the boiling point of said media. According to one example, the permeate recovery device is arranged to maintain a predetermined sub-atmospheric pressure in the annular space, which pressure is sufficient to prevent condensation of water therein.

Table 1

Pressure		Boiling point	
Psi	Bar	Deg. F	Deg. C
0,5	0,03	79,6	26,4
1	0,07	102	38,7
2	0,14	126	52,2
3	0,21	141	60,8
4	0,28	153	67,2
5	0,34	162	72,3
6	0,41	170	76,7
7	0,48	177	80,4
8	0,55	183	83,8
9	0,62	188	86,8
10	0,69	193	89,6
11	0,76	198	92,1
12	0,83	202	94,4
13	0,90	206	96,6
14	0,97	210	98,7
14,69	1,0	212	100

Table 1 shows the variation in boiling point (deg. F / deg. C) for water as the pressure (psi / bar) in the riser annulus is reduced. As can be seen from the table, the boiling point is reduced from 100 ℃ at 1 bar to 26,4 ℃ at 0,03 bar. Temperature of the production fluid at the manifold 11 where it enters the lower end of the riser can be 100℃. For relevant conditions, both CO_2 and H_2S have higher boiling points compared to H_2O. It is therefore water present in the annulus that governs the needed sub-atmospheric pressure. By lowering the pressure in the riser annulus sufficiently, the evaporation of water and other substances that can be harmful to the riser is facilitated. The temperature in the riser annulus will vary depending on the temperature of the production fluid and the design of the riser, in particular with respect to the insulation level of the riser. For a typical riser, the annulus temperature can be within the range 30 to 80 °C. At these temperatures both CO_2 and H_2S will be in gaseous state. Lowering the pressure in annulus will lower the partial pressures of these gases and reduce/prevent their contribution to corrosion fatigue. Continuous venting will be the preferred operating method, although intermittent venting may be used.

A pressure sensor 24 is arranged to monitor the sub-atmospheric pressure in the annulus and to control operation of the permeate recovery device. In this example, the pressure sensor 24 is shown at the upper end of the riser 12. The pressure sensor 24 is connected to an electronic control unit 25 that controls the operation of the vacuum pump 20, so that a predetermined sub-atmospheric pressure can be maintained in the annular space. The pressure sensor 24 is arranged to monitor pressure variations in the annular space, indicating a leakage in the riser 12.

A flow meter is arranged in the recovery line 21 downstream of the one-way valve 23, in order to monitor the flow of permeate from the riser 12. Using the flow meter it is possible to determine the volume of the riser annulus. This can be achieved by stopping the vacuum pump and allowing the pressure to reach a predetermined level, for instance atmospheric pressure. The flow meter is then used for measuring the volume of gas pumped out of the annulus to reach, for instance, half the atmospheric pressure. The volume of the riser annulus can then be calculated using the gas equation:

$p*V/T = \text{constant}$,   where;

p = pressure
V = volume
T = temperature.

On the production vessel, liquid permeate can be drained into a sample bottle 26 from the conduit connected to the storage tank 22 and samples taken for monitoring. The gases can be safely disposed of to the facility's gas vent system. The arrangement allows measurement and analysis of permeated gas / liquid from a subsea location as opposed to directly venting to atmosphere and can ensure that the necessary venting process does not damage the environment. By determining the chemical composition of the permeate, the source of the leakage can be determined. For instance, if the permeate comprises an increased hydrocarbon content, then the leak is located in the inner sheath. Similarly, if the permeate comprises an increased water content, then the leak is located in the outer sheath.

However, in order to handle an emergency, the riser venting arrangement according to the invention can be provided with an optional flare (not shown) connected to the storage tank 22, wherein excess gaseous permeate can be vented from the storage tank 22 to the facility's gas vent system to the flare.

The riser venting arrangement is preferably, but not necessarily, intended for a flexible riser where the inner portion comprises a wound metal carcass covered by a pressure sheath and the outer portion comprises layers of flexible armour and an outer protective sheath. The particular design of the flexible riser is not relevant to the invention as such. The invention can be applied to any suitable riser configuration where it is desirable to vent the annulus between the pressure sheath and the outer protective sheath.

Figure 3 shows a schematic illustration of the layers making up a flexible riser 30. In this example, the riser comprises, from the inner to the outer layer, an internal load bearing structural layer 31 arranged to prevent collapse of inner polymer layers due to pipe decompression and/or external hydrostatic pressure, often termed a carcass, a fluid tight pressure barrier 32, load bearing structural layers 33, 34 and an outer layer 35 or protective sheath. The carcass forms the innermost layer of the flexible riser and is commonly made from stainless steel flat strip that is shaped and wound into an interlocking profiled tube. For certain riser applications the innermost carcass can be voided.

The pressure barrier is encased by a pressure amour and a tensile armour. The pressure armour 33 is arranged to withstand the hoop stress in the riser wall caused by the inner fluid pressure. The pressure armour is wound around the pressure barrier and comprises interlocking wires. Figure 3 shows two pressure armour layers. The tensile armour 34 comprises layers of flat, rectangular wires cross-wound in pairs and is used to resist tensile load on the flexible riser. The outer layer 35 or protective sheath is an outer polymer sheath that can be made from the same material as the pressure barrier. The outer layer 35 is a barrier against seawater and provides a level of protection for the armour layers. In this example, the annulus is located between the pressure barrier 32 and the outer layer 35.

The invention is not limited to the above embodiments, but may be varied freely within the scope of the claims.

CLAIMS

1. Riser venting arrangement in a subsea riser used for conveying hydrocarbons, the riser comprising an inner sheath and an outer sheath separated by an annular space, characterized in that the venting arrangement further comprises a permeate recovery device for recovering permeate passing through the inner sheath into the annular space by creating a sub-atmospheric pressure in the annular space, which permeate recovery device is connected to the riser and communicates with a permeate recovery line.

2. Riser venting arrangement according to claim 1, characterized in that the permeate recovery device is connected to the riser adjacent an upper region of the riser.

3. Riser venting arrangement according to claim 1 or 2, characterized in that a permeate storage tank is connected to the recovery line.

4. Riser venting arrangement according to any one of claims 1-3, characterized in that a one-way valve is arranged in the recovery line between the permeate recovery device and the storage tank, preventing flow from the permeate recovery line into the annular space.

5. Riser venting arrangement according to any one of claims 1-4, characterized in that the permeate recovery device is a vacuum pump.

6. Riser venting arrangement according to any one of claims 1-5, characterized in that the permeate recovery device is arranged to recover permeate in gaseous form from the annular space.

7. Riser venting arrangement according to any one of claims 1-6, characterized in that the permeate recovery device is arranged to maintain a predetermined sub-atmospheric pressure in the annular space,

which pressure is sufficient to prevent condensation of permeate therein and reduce the partial pressures of corrosive gases.

8. Riser venting arrangement according to any one of claims 1-7, characterized in that a pressure sensor is arranged to monitor the sub-atmospheric pressure in the annular space and to control operation of the permeate recovery device.

9. Riser venting arrangement according to claim 8, characterized in that the pressure sensor is arranged to monitor pressure variations in the annular space, indicating a leakage in the riser.

10. Riser venting arrangement according to any one of claims 1-9, characterized in that the riser is a flexible riser comprises a metal carcass covered by a pressure sheath armour layers and an external sheath, where the pressure sheath and the external sheath surrounds the annular space.

11. Riser venting arrangement according to any one of claims 1-10, characterized in that the storage tank is connected to a vent system, wherein excess gaseous permeate is vented from the storage tank to the vent system.

12. Riser venting method used to vent a subsea riser for conveying hydrocarbons, the riser comprising an inner sheath and an outer sheath separated by an annular space, the method comprising the steps of

- operating a permeate recovery device creating a sub-atmospheric pressure in the annular space, and
- drawing vapour from the annular space through the permeate recovery device, and
- lowering partial pressures of gases in the annulus.

13. Riser venting method according to claim 12, characterized by drawing vapour from the annular space past a one-way valve downstream of the permeate recovery device.

14. Riser venting method according to claim 12 or 13, characterized by drawing vapour from the annular space into a permeate storage tank downstream of the one-way valve.

15. Riser venting method according to any one of claims 12-14, characterized by maintaining a predetermined sub-atmospheric pressure in the annular space, which pressure is sufficient to prevent condensation of water therein.

16. Riser venting method according to any one of claims 12-15, characterized by monitoring the sub-atmospheric pressure and controlling operation of the permeate recovery device.

17. Riser venting method according to any one of claims 12-16, characterized by monitoring pressure variations in the annular space, indicating a leakage in the riser.

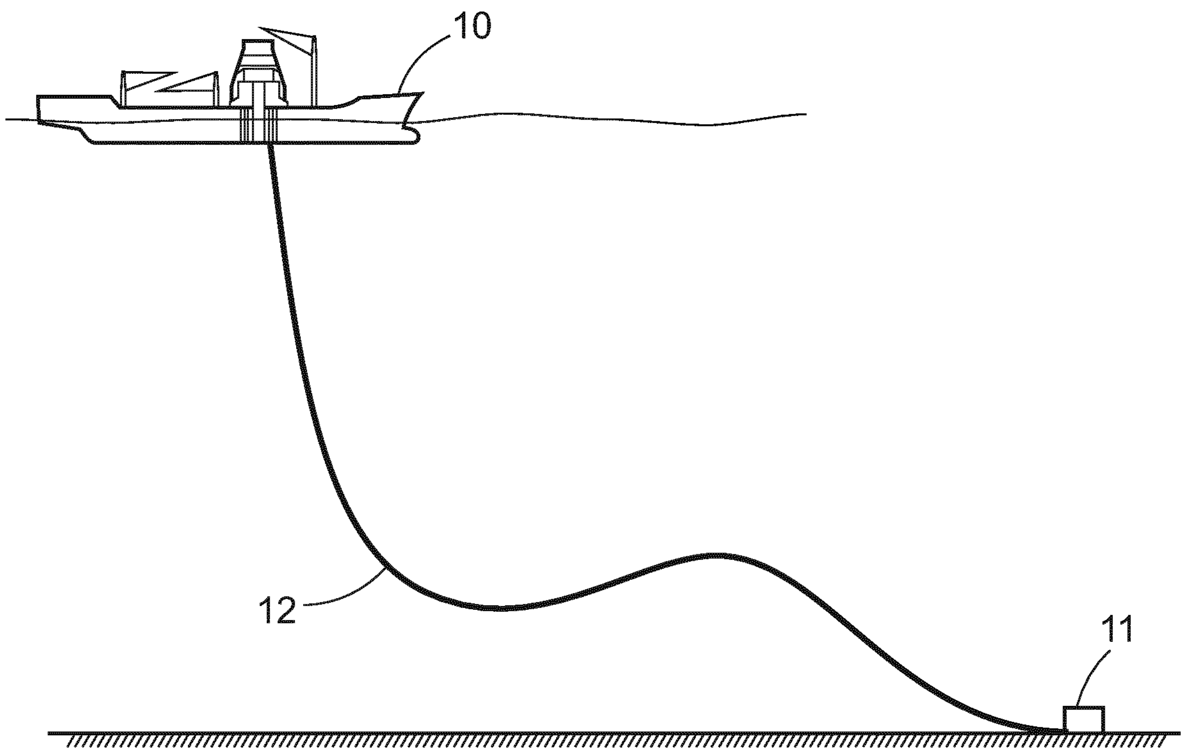

Fig.1

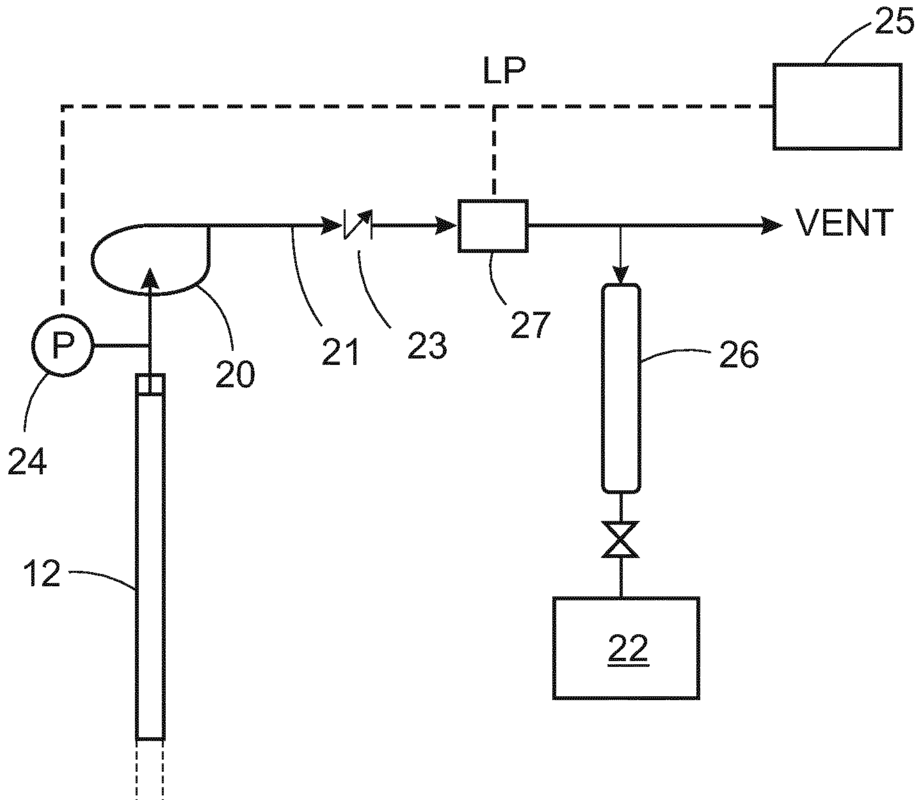

Fig.2

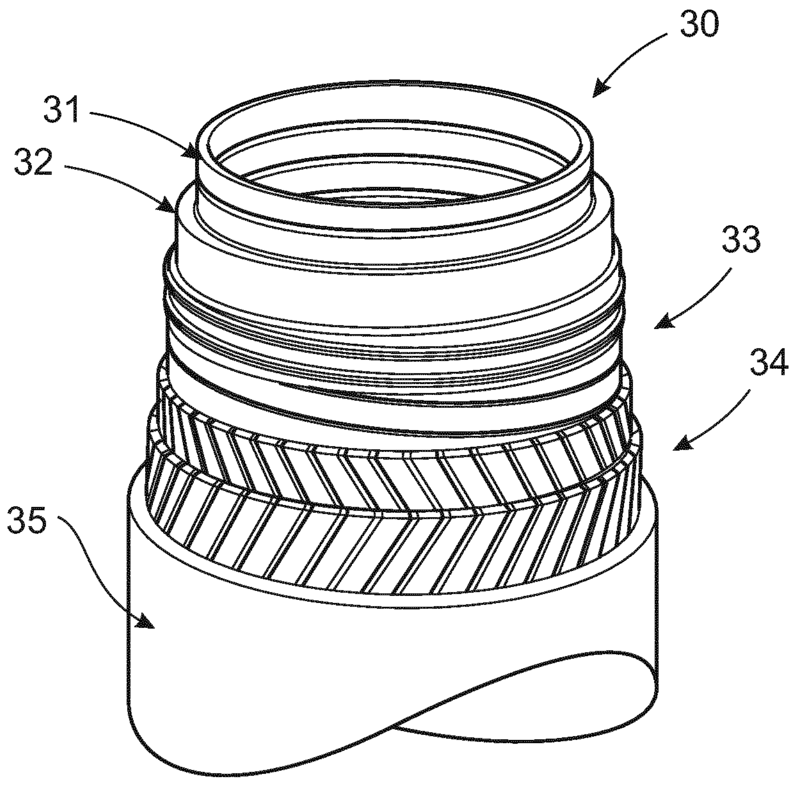

Fig.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/062233

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B17/01 E21B43/01 E21B47/10 F16L11/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B G01M F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 634 388 B1 (TAYLOR JACK CURTIS [US] ET AL) 21 October 2003 (2003-10-21) Document D1 in Opposition procedure against EP1656517 family of US2008149209; claims 16,17; figure 12 vacuum pump 56; column 6, lines 6-21 column 8, line 66 - column 9, line 9 the whole document column 1, lines 28-46 & US 5 072 622 A (ROACH MAX J [US] ET AL) 17 December 1991 (1991-12-17) cited in US6634388 -----	1,2, 4-13, 15-17

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 March 2013	13/03/2013
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer van Berlo, André

1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/062233

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/026801 A1 (SHELL INT RESEARCH [NL]; OUT JOHANNES MARTINUS MARIA [NL]) 10 March 2011 (2011-03-10) the whole document	1-3,5-7, 10-13, 15,16
X	US 2008/149209 A1 (FELIX-HENRY ANTOINE [FR]) 26 June 2008 (2008-06-26) paragraphs [0017], [0057], [0064], [0065]; claims 6,9; figures 1,2 the whole document	1,5-8, 10,12
A	WO 2010/118342 A1 (SCHLUMBERGER TECHNOLOGY CORP [US]; RAMOS ROGERIO TADEU [GB]; KIMMINAU) 14 October 2010 (2010-10-14) annular void can be considered storage; figures 1-4	1
A	DOMINIQUE DION ET AL: "Flexible Pipe Integrity Monitoring: A New System to Assess the Flexible Pipe Annulus Condition", PROCEEDINGS OF OFFSHORE TECHNOLOGY CONFERENCE, 1 January 2010 (2010-01-01), XP055054466, DOI: 10.4043/20973-MS ISBN: 978-1-55-563304-2 the whole document figure 2	1
A	WO 2010/036792 A2 (SCHLUMBERGER TECHNOLOGY CORP [US]; SCHLUMBERGER CA LTD [CA]; SCHLUMBER) 1 April 2010 (2010-04-01) paragraphs [0010] - [0012]; claims 17,18; figure 5 the whole document	1,12
A	WO 2009/106078 A1 (NKT FLEXIBLES IS [DK]; KRISTIANSEN MIKAEL [DK]; WEPPENAAR NICKY [DK]) 3 September 2009 (2009-09-03) figure 6 figures 1-5	14
A	WO 00/17479 A1 (NKT FLEXIBLES A S [DK]; GLEJBOEL KRISTIAN [DK]) 30 March 2000 (2000-03-30) figures 1,2	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/062233

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6634388	B1	21-10-2003	NONE			
WO 2011026801	A1	10-03-2011	NONE			
US 2008149209	A1	26-06-2008	AT	545816	T	15-03-2012
			BR	PI0413507	A	10-10-2006
			CA	2535363	A1	03-03-2005
			DK	1656517	T3	11-06-2012
			EP	1656517	A1	17-05-2006
			FR	2858841	A1	18-02-2005
			OA	13239	A	31-01-2007
			US	2008149209	A1	26-06-2008
			WO	2005019715	A1	03-03-2005
WO 2010118342	A1	14-10-2010	EP	2417432	A1	15-02-2012
			US	2012170610	A1	05-07-2012
			WO	2010118342	A1	14-10-2010
WO 2010036792	A2	01-04-2010	EP	2329106	A2	08-06-2011
			US	2011247826	A1	13-10-2011
			WO	2010036792	A2	01-04-2010
WO 2009106078	A1	03-09-2009	CA	2716795	A1	03-09-2009
			EP	2265929	A1	29-12-2010
			US	2011026031	A1	03-02-2011
			WO	2009106078	A1	03-09-2009
WO 0017479	A1	30-03-2000	AT	239857	T	15-05-2003
			AU	5727799	A	10-04-2000
			BR	9913914	A	12-06-2001
			CA	2345129	A1	30-03-2000
			DE	69907708	D1	12-06-2003
			EP	1119684	A1	01-08-2001
			ID	29896	A	18-10-2001
			NO	20011474	A	25-05-2001
			US	6634387	B1	21-10-2003
			WO	0017479	A1	30-03-2000