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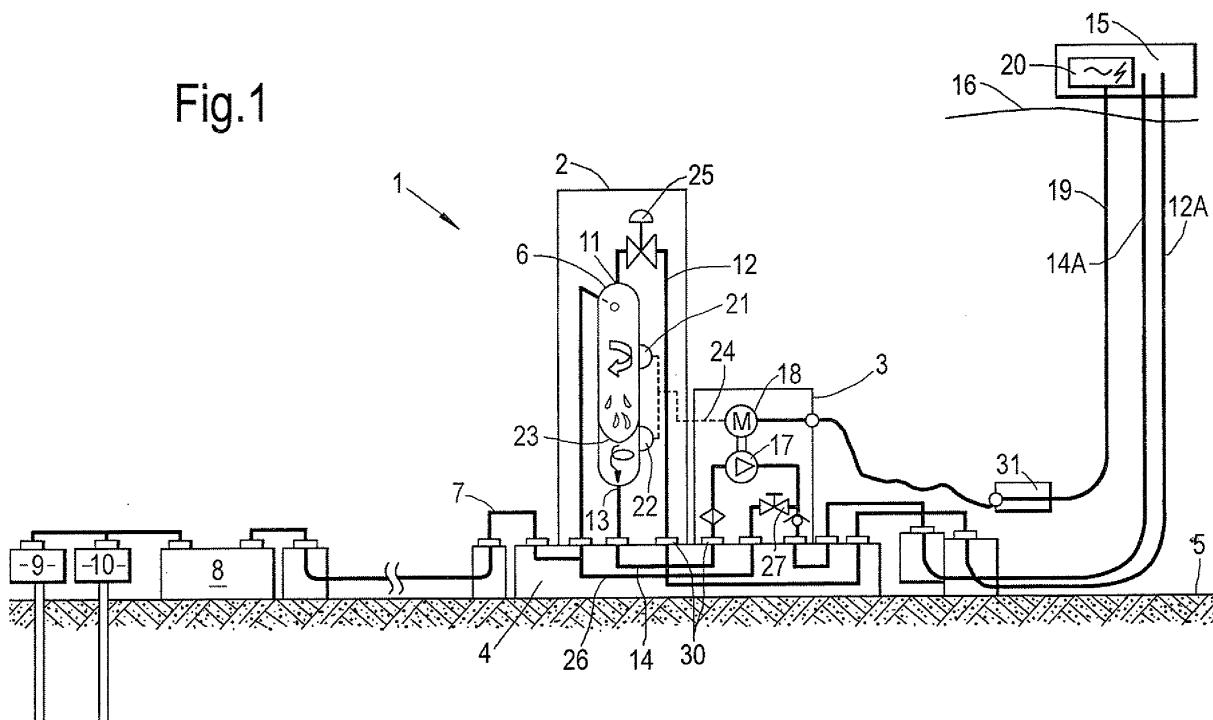
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(54) **Method and system for subsea processing of multiphase well effluents**

(57) A method and system are disclosed for subsea processing multiphase well effluents comprising natural gas and liquid from a subsea hydrocarbon containing formation, which system (1) comprises:
- a fluid separation vessel (6) which is connected to a downstream end of a multiphase well effluent transportation conduit (7);
- a liquid level transmitter assembly (21,22) for monitoring the gas liquid interface (23) in the fluid separation vessel (6);

- a liquid enriched fluid transportation flowline (14) connected at or near the bottom (13) of the fluid separation vessel (6) and a gas enriched fluid transportation flowline (12) connected at or near a top (11) of the fluid separation vessel (6);
- a pump (17) connected to an electric motor (18); and
- a fast acting variable speed drive system, which is coupled to the liquid level controller which adjusts the pump and motor speed setpoint within 2 seconds to maintain the liquid level in the vessel at a predetermined setpoint.

Fig.1



Description

Background of the Invention

[0001] The invention relates to a method and system for subsea processing of multiphase well effluents.

[0002] Such a method and system are known from US patent 7,210,530. In the known system a fluid separation vessel is arranged at or near the seabed, in which vessel a multiphase well effluent mixture is separated into gaseous and liquid fractions, which are removed from the vessel through gas and liquid flowlines that are connected near the top and bottom of the vessel.

[0003] A disadvantage of the known subsea processing system is that it comprises a hydraulic pump with a relatively slow response time of at least about twenty seconds and typically about sixty seconds, which hydraulic pump is combined with a differential pressure transducer to control the flowrate of the liquid flowing through the liquid flowline.

[0004] A further disadvantage of the known subsea processing system is that it will require a low level shutdown system to protect the pump from mechanical damage if the separator is drained. It is an object of the invention to alleviate these disadvantages.

Summary of the Invention

[0005] In accordance with the invention there is provided a method of subsea processing multiphase well effluents produced from an underwater hydrocarbon containing formation, the method comprising:

- arranging a fluid separation vessel at or near the seabed;
- inducing the multiphase well effluents to flow from the formation through a well and an underwater multiphase well effluent transportation conduit to the fluid separation vessel;
- separating the mixture in the fluid separation vessel into gas and liquid enriched fluid fractions;
- transferring the liquid and gas enriched fluid fraction to surface crude oil gas processing facilities via separate flowlines;
- boosting the pressure in the flowline for transferring the liquid enriched fluid fraction by a pump of which the pump speed is adjusted in response to variation of a gas liquid interface level in the separation vessel;
- wherein the pump is driven by an electric motor of which the speed is controlled by a fast acting variable speed drive system.

[0006] A liquid level transmitter measures the liquid level in the separation vessel and transmits the level signal to a controller, which adjusts the pump speed setpoint in a cascade arrangement to maintain the liquid level at a predetermined setpoint. The level controller is tuned to provide extremely fast action for handling level distur-

bances caused by changes in the liquid feed rate, such that the pump speed setpoint is almost instantly adjusted to respond to changes in liquid level. However the level controller also provides stable pump speed when the liquid feed rate is stable.

[0007] The fast acting variable speed drive receives its speed setpoint from the level controller and increases or decreases the pump speed within 2 seconds, being limited only by the physical capabilities of the particular variable speed drive. This fast acting level controller enables the use of compact separation systems as the liquid interface level can now be maintained within a small boundary.

[0008] It is also preferred that the pump is a gas tolerant or multiphase pump, to ensure occasional separator drainage or gas surge can be tolerated when severe liquid feed disturbances occur which may require a faster pump speed response than is physically possible with the variable speed drive.

[0009] It is furthermore preferred that:

- the flowline for transferring the gas enriched fluid fraction is connected at or near the top of the separation vessel and the flowline for transferring the liquid enriched fluid fraction is connected at or near the bottom of the gravity separation vessel, that the flowline for transferring the gas enriched fluid fraction is equipped with a liquid overflow valve, which is closed if liquid enters the valve,
- the separation vessel and liquid valve overflow valve are arranged in a separator module which is retrievably mounted on a pump station base at the seabed and
- the pump and the electric pump motor are mounted in a pump module, which is retrievably mounted on the pump station base.

[0010] Furthermore, an inlet of a fluid recirculation conduit may be connected to the liquid enriched fluid transportation conduit at a location downstream of the pump and an outlet of the fluid recirculation conduit is connected to the multiphase well effluent transportation conduit, which conduit is equipped with a valve, which is opened during start up of the pump and which is subsequently closed.

[0011] In accordance with the invention there is furthermore provided a system for subsea processing multiphase well effluents comprising natural gas and liquid from an underwater hydrocarbon containing formation, the system comprising:

- a fluid separation vessel which is connected to a downstream end of a multiphase well effluent transportation conduit;
- a liquid level transmitter assembly for monitoring the gas liquid interface in the fluid separation vessel;
- a liquid level controller which receives the signal from the level transmitter and generates a pump speed

setpoint for controlling the liquid level to a predetermined setpoint;

- a liquid enriched fluid transportation flowline connected at or near the bottom of the fluid separation vessel and a gas enriched fluid transportation flowline connected at or near a top of the fluid separation vessel;
- a pump connected to an electric motor;
- a fast acting variable speed drive system, which is coupled to the liquid level controller which control the pump and motor speed as fast as physically possible, within 2 seconds, to achieve the pump speed setpoint from the level controller.

[0012] These and other features, embodiments and advantages of the method and system according to the invention are described in the accompanying claims, abstract and the following detailed description of a preferred embodiment disclosed in the accompanying drawing in which reference numerals are used which refer to corresponding reference numerals that are shown in the drawings.

Brief Description of the Drawing

[0013]

FIG.1 is a schematic view of a subsea processing system according to the invention.

Detailed Description of the Depicted Embodiment

[0014] FIG.1 shows a subsea processing system 1 according to the invention comprising a separation module 2 and a pump module 3 that are retrievably mounted on a base 4, which is mounted on the seabed 5.

[0015] The separation module 2 comprises a gas-liquid separation vessel 6, which is connected to a multiphase well effluent flowline 7, which is connected via a manifold 8 to a pair of subsea gas wells 9 and 10 which produce a multiphase flow mixture of natural gas, water, condensates and optionally crude oil from an underwater gas reservoir (not shown). The gas-liquid separation vessel 6 is provided with an upper outlet 11 for discharging a gas enriched fluid fraction into a gas transportation conduit 12 and with a lower outlet 13 for discharging a liquid enriched fluid fraction into a liquid transportation conduit 14. The gas and liquid transportation conduits 12 and 14 comprise vertical riser sections 12A, 14A, which are suspended below a floating platform 15, which floats at the water surface 16.

[0016] In order to enhance the liquid production and reduce the backpressure of the hydrostatic liquid column in the liquid filled riser section 14A on the separation vessel 6 the pump module 3 comprises a gas tolerant liquid pump 17, which is driven by an electric motor 18 that is powered via an electrical cable 19 by an electric power source 20 at the platform 15.

[0017] The electric motor 18 is equipped with a fast acting variable speed drive system, which is coupled, as indicated by dashed line 24, to an assembly of two liquid level transmitters 21 and 22 and a level controller which monitor the liquid level 23 in the separation vessel 6. The level controller provides the speed setpoint to the fast acting variable speed drive system. The level controller will increase the speed of the motor and pump assembly 17,18 within 1 to 2 seconds if the liquid level increases above its setpoint 21 and the level controller will decrease the speed of the motor and pump assembly 17,18 within 1 to 2 seconds if the liquid level 23 drops below the predetermined liquid level controller setpoint 21.

[0018] In order to inhibit liquid to flow into the gas transportation conduit 12 in case of a liquid surge a liquid overflow valve 25 is arranged in the gas transportation conduit 12 in the vicinity of the upper gas outlet 11, which valve automatically closes itself if a liquid surge enters the valve.

[0019] During start up of the pump 17 at least a fraction of the liquid discharged from the lower liquid outlet 13 is circulated back to the multiphase well effluent flowline 7 through a liquid recycling conduit 26, which is equipped with a valve 27, which is opened during the pump start up phase and which is subsequently gradually closed. The valve 27 may comprise a conventional subsea choke and an on-off valve, which does not need to be fast acting as failure to control the recycle flow rate will not have a detrimental effect on the multiphase pump 17.

[0020] Thus an advantage of the subsea processing system according to the invention is that the valves 25 and 27 may be simple on off valves, which do not require a complex dynamic control of the valve openings and that the electric motor 18 is the only subsea component which is dynamically controlled by a fast acting variable speed drive system which receives its speed setpoint from a level controller.

[0021] The modular construction of the system 1 allows replacement, inspection and/or repair of the retrievable pump and separator modules 3 and 2 by disconnecting the stab-in pipe joints 30 and the subsea power cable connector 31 and then lifting the pump and/or separator module 3,2 to a vessel at the water surface 16 for replacement inspection and/or repair.

[0022] It will be understood that the processing system 1 according to the invention may be installed at the bottom 5 of an ocean, sea, lake and/or river and that the term "subsea" as used in this specification and the accompanying claims should be interpreted extensively so that it embraces all these options.

Claims

1. A method of subsea processing multiphase well effluents produced from an underwater hydrocarbon containing formation, the method comprising:

- arranging a fluid separation vessel at or near the seabed;
 - inducing the multiphase well effluents to flow from the formation through a well and an underwater multiphase well effluent transportation conduit to the fluid separation vessel;
 - separating the mixture in the fluid separation vessel into gas and liquid enriched fluid fractions;
 - transferring the liquid and gas enriched fluid fraction to surface crude oil gas processing facilities via separate flowlines;
 - boosting the pressure in the flowline for transferring the liquid enriched fluid fraction by a pump of which the pump speed is adjusted in response to variation of a gas liquid interface level in the separation vessel;
 - wherein the pump is driven by an electric motor of which the speed is controlled by a fast acting variable speed drive system which is coupled to a liquid level controller, which monitors the liquid level in the separation vessel and which increases the pump speed within 2 seconds if the liquid level rises above a predetermined liquid level setpoint and decreases the pump speed within 2 seconds if the liquid level drops below the predetermined liquid level setpoint.
2. The method of claim 1, wherein the fast acting variable speed drive increases or decreases the pump speed in a cascade arrangement within 1 to 2 seconds if the liquid level is below the predetermined minimum level or above the predetermined maximum level.
 3. The method of claim 1, wherein the pump is a gas tolerant multiphase pump.
 4. The method of claim 3, wherein the pump is a positive displacement pump.
 5. The method of claim 4, wherein the pump is a twin screw pump.
 6. The method of claim 1, wherein the fluid separation vessel is a gravity separation vessel and the flowline for transferring the gas enriched fluid fraction is connected at or near the top of the gravity separation vessel and the flowline for transferring the liquid enriched fluid fraction is connected at or near the bottom of the gravity separation vessel.
 7. The method of claim 1, wherein the fluid separation vessel is a compact, for example cyclonic, separation vessel and the flowline for transferring the gas enriched fluid fraction is connected at or near the top of the gravity separation vessel and the flowline for transferring the liquid enriched fluid fraction is connected at or near the bottom of the gravity separation vessel.
 8. The method of claim 6, wherein the flowline for transferring the gas enriched fluid fraction is equipped with a liquid overflow valve, which is closed if liquid enters the valve.
 9. The method of claim 8, wherein the separation vessel and liquid valve overflow valve are arranged in a separator module which is retrievably mounted on a pump station base at the seabed.
 10. The method of claim 9, wherein the pump and the electric pump motor are mounted in a pump module, which is retrievably mounted on the pump station base.
 11. The method of claim 1, wherein an inlet of a fluid recirculation conduit is connected to the liquid enriched fluid transportation conduit at a location downstream of the pump and an outlet of the fluid recirculation conduit is connected to the multiphase well effluent transportation conduit, which conduit is equipped with a valve, which is opened during start up of the pump and which is subsequently closed.
 12. The method of claim 11, wherein the liquid overflow and pump recycle valves are slow acting valves, which is configured to be moved between a fully opened and a fully closed position over a time interval of typically around 20 seconds.
 13. A system for subsea processing multiphase well effluents comprising natural gas and liquid from an underwater hydrocarbon containing formation, the system comprising:
 - a fluid separation vessel which is connected to a downstream end of a multiphase well effluent transportation conduit;
 - a liquid level transmitter assembly for monitoring the gas liquid interface in the fluid separation vessel;
 - a liquid enriched fluid transportation flowline connected at or near the bottom of the fluid separation vessel and a gas enriched fluid transportation flowline connected at or near a top of the fluid separation vessel;
 - a pump connected to an electric motor;
 - a fast acting variable speed drive system, which is coupled to the liquid level controller which provides the pump and motor speed setpoint in a cascade arrangement to control the level to a predetermined setpoint, and which is configured to bring the pump and motor speed to the designated speed setpoint within 2 seconds.

14. The system of claim 13, wherein the fast acting variable speed drive system is configured to increase and decrease the pump and motor speed in a cascade arrangement within 1 to 2 seconds, to achieve the speed setpoint provided by the level controller. 5

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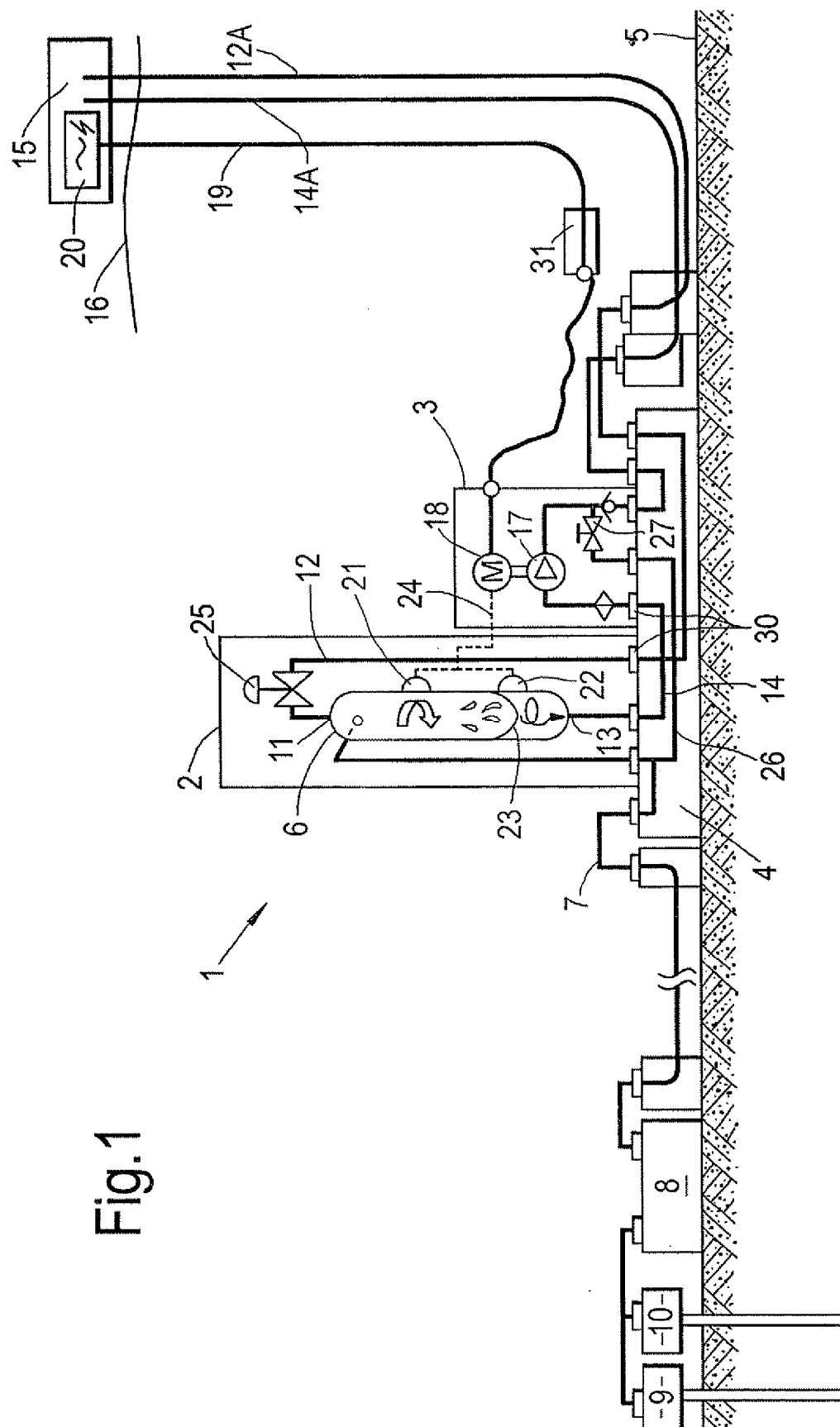


Fig. 1



EUROPEAN SEARCH REPORT

Application Number
EP 08 16 1579

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 3 391 734 A (TOWNSEND) 9 July 1968 (1968-07-09) * column 5, line 60 - line 71 * -----	1,3-7, 13,14	INV. E21B43/36 E21B43/01
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D,A	US 7 210 530 B2 (LUSH ET AL.) 1 May 2007 (2007-05-01) * column 2, line 57 - line 65 * -----	7	
Y	US 5 486 106 A (HEHL) 23 January 1996 (1996-01-23) * column 4, line 10 - line 12 * -----	14	
			TECHNICAL FIELDS SEARCHED (IPC)
			E21B F04D F04B
<p>1 The present search report has been drawn up for all claims</p>			
Place of search		Date of completion of the search	Examiner
The Hague		18 June 2009	Rampelmann, Klaus
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03.82 (P04C01)



Application Number

EP 08 16 1579

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1, 3-7, 13, 14

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



**LACK OF UNITY OF INVENTION
SHEET B**

Application Number
EP 08 16 1579

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1, 3-7, 13, 14

Method and system for subsea processing multiphase fluids
using fast acting variable speed drive

2. claim: 2

Cascade arrangement for variable speed drive

3. claims: 8-10

Gas flowline with liquid overflow valve

4. claims: 11-12

Fluid recirculation to pump inlet

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 16 1579

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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18-06-2009

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