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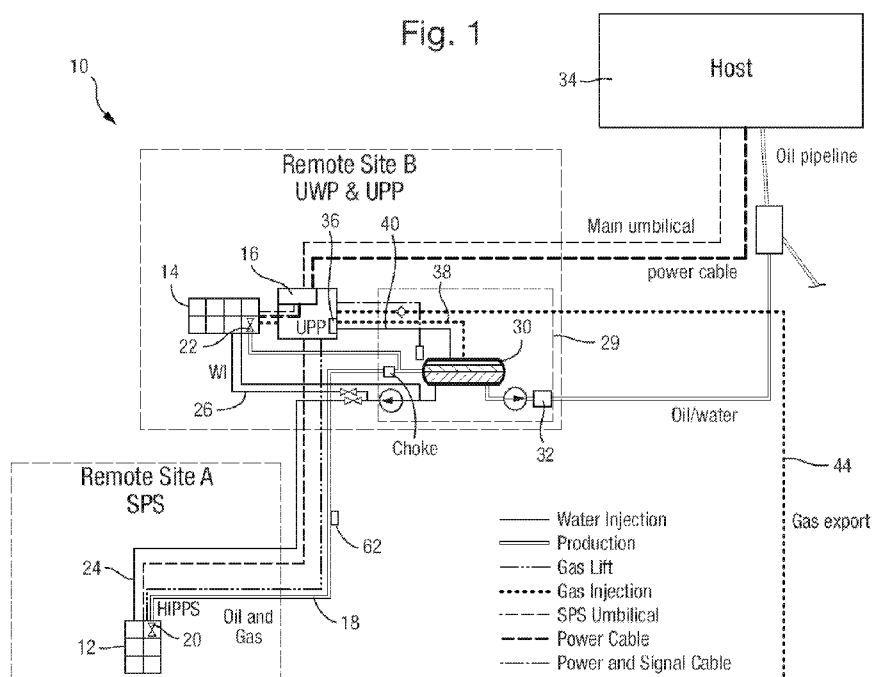
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(54) Title: PRESSURE PROTECTION FOR AN OFFSHORE PLATFORM



(57) Abstract: A method for pressure protection of an offshore platform (14, 16) of an oil and gas installation, the offshore platform (14, 16) being connected to source of hydrocarbons via a pipeline (18), the method comprising: using a safe link device (62) at the pipeline (18); wherein the safe link device (62) is located subsea and outside of the safety zone of the platform (14, 16); protecting the platform via a subsea High Integrity Pressure Protection System (HIPPS) for the platform (14, 16) and/or the pipeline (18); and wherein the safe link device (62) is arranged to activate to release pressure from the pipeline (18) when the pressure exceeds a preset threshold that is above the normal ultimate limit state pressure for the platform (14, 16).



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PRESSURE PROTECTION FOR AN OFFSHORE PLATFORM

The present invention relates to a method for pressure protection for an offshore platform of an oil and gas installation and to an offshore platform with a pressure protection device in accordance with the method.

It is required for offshore platforms to be designed taking into account the possibility of over-pressure and/or of a fire, amongst other safety risks, and this is of particular relevance for oil and gas installations due to the presence of combustible hydrocarbons under potentially high pressure. Whilst steps are taken to minimise the risks, it is also necessary to take account of events such as a possible over-pressure or a fire and the damage that this might cause. Offshore platforms typically incorporate a mechanism for depressurisation of hydrocarbons and safe removal of some or all of the hydrocarbon inventory from the platform during a fire. Typically a flare or vent is used, especially in the case of installations where personnel may be present either permanently (i.e. a manned platform) or temporarily during maintenance (such as with an unmanned platform). The same depressurisation mechanism is also available to release excess pressure in the event that an over-pressure occurs in pipelines connected to the platform.

Viewed from a first aspect, the invention provides a method for pressure protection of an offshore platform of an oil and gas installation, the offshore platform being connected to source of hydrocarbons via a pipeline, the method comprising: using a safe link device at the pipeline; wherein the safe link device is located subsea and outside of the safety zone of the platform; protecting the platform via a subsea High Integrity Pressure Protection System (HIPPS) for the platform and/or the pipeline; and wherein the safe link device is arranged to activate to release pressure from the pipeline when the pressure exceeds a preset threshold that is above the design pressure for the platform.

Thus, the method involves the use of an added safety feature in the form of the safe link device. This protects the platform from excessive pressures, whilst allowing the platform to operate normally without any hindrance by permitting pressures up to at least the design pressure of the platform. It should be noted that in this context the design pressure is a topside pressure limit for normal use of the platform. The platform may be able to withstand larger pressures during testing (often termed a test pressure) and also in an emergency such as when there is an accident or equipment failure (such as a maximum allowable accumulated pressure). The preset threshold may allow for pressures up to the ultimate limit state for the pipeline.

The method of the first aspect has various advantages. It allows for the absence of other emergency pressure release devices on the platform itself (such as a flare or the like). It also enhances the safety of the platform and allows for alternative safety solutions to be

use on board the platform and for subsea equipment without any concerns for the safety of personnel that are permanently or temporarily present on the platform. In particular, the subsea pipeline and/or the platform is provided with a High Integrity Pressure Protection System (HIPPS) as is known in the art, where sensors and computer controlled systems act to maintain safety without the use of depressurisation through a physical safe link or otherwise. It is preferred that the safe link device is a physical safe link using a carefully calibrated structure that breaks to release the pressure when the pressure exceeds the preset threshold. This then results in a useful enhancement to the pressure protection when the safe link is combined with subsea HIPPS and/or platform HIPPS since the two systems are reliant on two different principles of operation.

The safe link device releases the pressure from the pipeline when it exceeds a set threshold defined based on a maximum permitted pressure at the platform. It is preferred for the safe link device to be operable only for a single use and/or for a physical intervention to be required to replace and/or reset the safe link device after it has been actuated. The safe link device is advantageously a physically triggered device, i.e. not reliant on sensors or actuators. Any suitable pressure activated mechanism may be used to achieve this. For example, the safe link device may be a structure or component in the pipeline that is designed to burst at a set pressure, such as a valve with a breakable pin that will fail at the required pressure, a rupture disc, or any other similar physical pressure relief mechanism that can be reliably designed to activate at the required pressure differential between the pipeline and the external environment.

In one example the safe link device comprises a rupture disc. The rupture disc will break when the pipeline pressure exceeds the preset threshold. Thus, the rupture disc may be designed and calibrated based on the platform requirements and subsea conditions (e.g. temperature, pressure) in order to rupture at the present threshold pressure.

The safe link device may be arranged so that the pipeline vents to the environment when the safe link device is triggered. Alternatively there may be systems in place to capture the contents of the pipeline without hindering the pressure relief function of the safe link device. The latter provides environmental benefits as potentially damaging hydrocarbons are not released into the environment.

The safe link device is located subsea and outside of the safety zone of the platform and may for example be 500m or more from the platform. The method may include using multiple safe link devices for redundancy and/or the (or each) safe link device may comprise multiple pressure activated mechanisms for redundancy. This can involve the use of several of the same type of device, or the use of multiple different types of device.

The platform is further protected by a HIPPS, which may be a subsea HIPPS for the pipeline and optionally other subsea equipment, or may be a platform HIPPS. As noted

above there is an advantage from the combination of a HIPPS and the safe link device. The use of the safe link facilitates a safe implementation of a subsea HIPPS even for a manned platform, or a platform that is normally unmanned but may have personnel present for maintenance. Where both of a HIPPS and a safe link device are present then the HIPPS should act to control the pressure to a lower level than the safe link device, which activates at a preset threshold that is above the design pressure for the platform. Thus, the safe link device provides a failsafe for the subsea HIPPS. A platform HIPPS may also be present, although this may be superfluous since the combination of subsea HIPPS and the safe link device will have acceptable reliability for protecting the platform or other topside installation against pressure above the safe link set point. Thus, a combination of subsea HIPPS and the safe link device can fully protect the platform with equivalent reduced topside design pressure, making additional topside pressure protection of these sections unnecessary.

The offshore platform may be connected to another platform with the safe link device acting to protect both platforms. The installation may comprise multiple platforms with separate safe link devices for each platform or safe link devices that act to protect several platforms at once. The best implementation may depend on the particular arrangement of a given installation and factors such as the spacing between platforms and the interconnectivity of the platforms.

The preset threshold for activation of the safe link device may be determined based on several factors including the normal operating conditions for the platform, whether or not a HIPPS is present, pressure limits on equipment on the platform, wellhead shut-in pressure, and probability functions relating to the pressure probability for the installation and/or for the platform. The preset threshold may be above the normal operating pressure for the platform and hence above the design pressure for the platform. The preset threshold may also be above the ultimate limit state for the pipeline. As noted above, where a subsea HIPPS or a platform HIPPS is present then the preset threshold would also be set to be above pressures that could be controlled and safely contained using the HIPPS. The preset threshold may be below the maximum allowable accumulated pressure for the platform(s) and/or below pressures that would cause failure of the equipment on the platforms. It is preferably below the accidental limit state pressure of the pipeline. The preset threshold would typically be set to be in a relatively small range, such as a range of 20 barg, and it may for example be in the range 300-320 barg, 430-450 barg or 520-540 barg depending on the specification for the platform and the pipeline. It will be appreciated that the system is not limited to any particular pressure range and the safe link could be implemented in higher or lower pressure pipelines and for higher or lower pressure platforms.

It will be appreciated that the use of the safe link device reduces or eliminates the need for additional topside pressure protection, and this means that the platform can be

operated without the need for a further emergency depressurisation device for physical pressure relief. Thus, the method may include arranging the platform such that there is no mechanism for emergency depressurisation of a hydrocarbon inventory of the platform in the event of a fire or other emergency that causes an over-pressure.

5 The absence of depressurisation such as a flare can reduce the size of the platform, and whilst the lack of depressurisation generates an added risk this risk is mitigated by the safe link device, and may further be mitigated by the optional HIPPS.

 In some cases the platform may have no depressurisation mechanism of any type, although it may sometimes be useful to allow for a cold vent system for use in maintenance.

10 It will be appreciated by those skilled in this field that there can be a capability for a slow speed depressurisation for use in maintenance (for example over several minutes or hours), whilst also having no ability for emergency depressurisation, which should occur at high speed with emission of large amounts of hydrocarbons in a short space of time, within seconds for example. Thus, in example methods, there is advantageously no emergency
15 depressurisation and thus there may be no flare, in particular there may be no hot flare and preferably no cold flare. For example there may be no large bore cold vent. The method may hence include the equipment and piping being left at operating pressure until the safe link device is triggered and pressure is released via the safe link device (or until the optional HIPPS is triggered), and thus the equipment and piping is not brought down to atmospheric
20 pressure in the event of a fire, but instead an operating pressure is left in the system. The pressure may change as a result of operation of other equipment such as the isolation valves discussed below and/or a drain tank or similar. The piping on the platform may be isolated from wells that are located subsea or at a separate structure and/or from pipelines having large inventories of oil or gas. For example, the method may include the use of
25 isolation valves at appropriate locations, with these isolation valves being arranged to isolate the hydrocarbon inventory of the platform in the event of a fire.

 The ability to avoid the use of a vent or flare for depressurisation on the platform can allow for reductions in size for the platform. There is considered to be a synergy in the combination of the proposed safe link device with a small sized platform. The decks may
30 have a maximum length and/or width of less than 30 m, optionally less than 25 m and in some examples less than 20 m. For example the largest deck(s) may be a square or rectangle with both length and width of less than 25 m or optionally less than 20 m. The platform may have five decks or fewer.

 The platform may be an unmanned platform, for example an unmanned production
35 platform or an unmanned wellhead platform. That is to say, it may be a platform that has no permanent personnel and may only be occupied for particular operations such as maintenance and/or installation of equipment. The unmanned platform may be a platform

where no personnel are required to be present for the platform to carry out its normal function, for example day-to-day functions relating to handling of oil and/or gas products at the platform. There are added advantages to making an unmanned platform as compact as possible, and thus a synergy between the proposed method including the absence of
5 emergency depressurisation and the use of this method with an unmanned platform.

An unmanned platform may be a platform with no provision of facilities for personnel to stay on the platform, for example there may be no shelters for personnel, no toilet facilities, no drinking water and/or no personnel operated communications equipment. The unmanned platform may also include no heli-deck and/or no lifeboat, and advantageously
10 may be accessed in normal use solely by the gangway or bridge, for example via a Walk to Work (W2W) system as discussed below.

An unmanned platform may alternatively or additionally be defined based on the relative amount of time that personnel are needed to be present on the platform during operation. This relative amount of time may be defined as maintenance hours needed per
15 annum, for example, and an unmanned platform may be a platform requiring fewer than 10,000 maintenance hours per year, optionally fewer than 5000 maintenance hours per year, perhaps fewer than 3000 maintenance hours per year. There is of course a clear inter-relationship between reducing the maintenance hours needed and the minimisation of fire protection, amongst other things. The current method is developed as a part of a general
20 philosophy of minimising the amount of, and complexity of, the equipment on the unmanned platform, thereby allowing for the smallest and most cost effective platform for a given capability in terms of providing a function in the oil and gas installation. When reductions in the size of the platform are combined with the proposed method then further gains are realised, since the evacuation time is reduced and thus the amount of passive fire protection
25 required by the method is also reduced.

In developing an unmanned platform it is a particular benefit for the maintenance hours to be kept to a minimum, since then the need for personnel on the platform is minimised. Therefore there is a synergy between the feature of an unmanned platform and removal of equipment such as the flare, as is enabled by the use of the proposed safe link
30 device. The safe link device may also enhance other safety aspects such as fire protection, as it may provide a mechanism for release of pressure that builds up during a fire, and this can reduce the requirement for fire protection in some situations. This again reduces the maintenance requirement and allows for further savings in terms of the size and complexity of the equipment on the platform.

35 Viewed from a second aspect, the invention provides a pressure protection system for a platform of an offshore oil and gas installation, wherein the platform is connected to a source of hydrocarbons via a pipeline, the pressure protection system comprising: a safe link

device at the pipeline; wherein the safe link device is located subsea and outside of the safety zone of the platform; a subsea High Integrity Pressure Protection System (HIPPS) at the platform and/or the pipeline for protecting the platform; and wherein the safe link device is arranged to activate to release pressure from the pipeline when the pressure exceeds a
5 preset threshold that is above the design pressure for the platform.

The system of this aspect may include features as discussed above in connection with the method of the first aspect.

The safe link device may include a physical safe link with a carefully designed structure that breaks to release the pressure when the pressure exceeds the preset
10 threshold. It is preferred for the safe link device to be operable only for a single use and/or for a physical intervention to be required to replace and/or reset the safe link device after it has been actuated. The safe link device is advantageously a physically triggered device, i.e. not reliant on sensors or actuators. Any suitable pressure activated mechanism may be used to achieve this. For example, the safe link device may be a structure or component in
15 the pipeline that is designed to burst at a set pressure, such as a valve with a breakable pin that will fail at the required pressure, a rupture disc, or any other similar physical pressure relief mechanism that can be reliably designed to activate at the required pressure differential between the pipeline and the external environment.

In one example the safe link device comprises a rupture disc. The rupture disc will
20 break when the pipeline pressure exceeds the preset threshold. Thus, the rupture disc may be designed and calibrated based on the platform requirements and subsea conditions (e.g. temperature, pressure) in order to rupture at the present threshold pressure.

The safe link device may be arranged so that the pipeline vents to the environment when the safe link device is triggered. Alternatively there may be systems in place to
25 capture the contents of the pipeline without hindering the pressure relief function of the safe link device. The latter provides environmental benefits as potentially damaging hydrocarbons are not released into the environment.

The safe link device is located subsea and outside of the safety zone of the platform and may for example be 500m or more from the platform. The system may comprise
30 multiple safe link devices for redundancy and/or the (or each) safe link device may comprise multiple pressure activated mechanisms for redundancy. This can involve the use of several of the same type of device, or the use of multiple different types of device.

In some examples the platform is further protected by a subsea HIPPS or a platform HIPPS. The use of the safe link facilitates a safe implementation of a HIPPS even for a
35 manned platform, or a platform that is normally unmanned but may have personnel present for maintenance. Where both of a HIPPS and a safe link device are present then the HIPPS should act to control the pressure to a lower level than the safe link device.

The offshore platform may be connected to another platform with the safe link device acting to protect both platforms. The installation may comprise multiple platforms with separate safe link devices for each platform or safe link devices that act to protect several platforms at once.

5 The preset threshold for activation of the safe link device may be determined based on several factors as discussed above.

 The invention extends to an offshore platform combined with the pressure protection system. The platform may include equipment and piping associated with the oil and gas installation; a hydrocarbon inventory including hydrocarbons in the equipment and piping;
10 and no mechanism for emergency depressurisation of a hydrocarbon inventory of the platform.

 This platform may have features in accordance with the discussion above in connection with the first aspect of the invention and optional features thereof. The platform may be arranged so that the equipment and piping are left at operating pressure in the event
15 of a fire until the safe link device (or HIPPS) is triggered. The piping on the platform may be isolated from wells that are located subsea or at a separate structure and/or from pipelines having large inventories of oil or gas. For example, isolation valves may be present at appropriate locations, with these isolation valves being arranged to isolate the hydrocarbon inventory of the platform in the event of a fire.

20 The pressure protection system can be for an unmanned platform, and where the platform is included then this may be an unmanned platform, such as an unmanned platform as defined above. There may be no shelters for personnel, no toilet facilities, no drinking water and/or no personnel operated communications equipment. The unmanned platform may also include no heli-deck and/or no lifeboat, and advantageously may be accessed in
25 normal use solely by a gangway or a bridge, for example via a Walk to Work (W2W) system as discussed above. The platform may thus include a gangway and/or a bridge for connecting the platform to a vessel and/or another platform.

 Certain embodiments of the present invention will now be described in greater detail by way of example only and with reference to the accompanying drawings in which:

30 Figures 1 and 2 are schematic diagrams showing the layout of an offshore field development;

 Figure 3 is a perspective view of a 3D model of an example platform with a topside twisted 45° relative to the jacket; and

 Figure 4 is an elevation of another example platform when viewed from the north.

35 The following is described in the context of a possible field development 10. A 6-slots subsea production system (SPS) 12 is proposed at a first remote site, A.

Approximately 12 km away, within a second remote site, B, is proposed an Unmanned Wellhead Platform (UWP) 14 and an Unmanned Processing Platform (UPP) 16.

The distance between remote site A and remote site B is approximately 12 km, while the distance from remote site B to the tie-in point at a host pipeline is approximately 34 km.

- 5 A schematic illustration of the pipeline systems is shown in Figures 1 and 2. The water depth both at remote site A and remote site B and in the host area is in the range of 100 to 110 metres, and the seabed bathymetry is in general flat with no major features or pockmarks.

Oil, gas and water from the reservoir of remote site A are produced to the SPS 12.

- 10 The well fluid is transported through an insulated and heat traced pipe-in-pipe pipeline 18 to remote site B. The UPP subsea and topside facility 16 at remote site B is protected from the high well shut-in pressure by a subsea high-integrity pressure protection system (HIPPS) system 20 as well as by a further HIPPS system that is on-board the UPP 16.

Oil, gas and water from the reservoir of remote site B are produced to the UWP 14.

- 15 The UPP subsea and topside facility 16 is further protected from the high well shut-in pressure by a topside HIPPS system 22 on the UWP 14.

In order to ensure that the UPP 16 provides a high degree of safety in over-pressure situations, in particular for periods when personnel are on board for maintenance, then a safe link device 62 is used to provide enhanced pressure protection. The function of the safe link device 62 is to release the pressure from the pipeline 18 when it exceeds a set threshold defined based on a maximum permitted pressure at the platform. As shown in Figures 1 and 2 the safe link device 62 is located in the pipeline 18 prior to both of the UPP 16 and UWP 14 and outside of the safety zone for the two platforms 14, 16. For example the safe link device 62 may be 500m or more away from the platforms 14, 16. Thus the safe link device 62 in this example acts to protect both platforms. It will be appreciated that the safe link device 62 could be located differently and may be placed to protect just the UPP 16, or just the UWP 14, or there may be separate safe link devices 62 for each platform 14, 16. The best implementation will depend on the features of a particular installation and the relative location of each platform and their safe zones.

- 30 The safe link device 62 is a structure in the pipeline 18 that will break or otherwise open to release the pressure from the pipeline 18 when it exceeds a set threshold defined based on a maximum permitted pressure at the platform. The pressure threshold within the pipeline 18 for activation of the safe link device 62 can be as discussed below. It should be appreciated that in general it is a local pressure differential that is needed to break the safe link device 62. Therefore, when designing the safe link device 6 the maximum permitted pressure for the pipeline needs to be considered with reference to the external pressure at the location of the safe link device 62, as well as also considering expected temperatures
- 35

with reference to the material properties of the device 62. The expected pressure differential is what sets the design parameters for the safe link device 62.

The maximum permitted pressure at the platform in this context will be above the normal operating pressure for the UWP 14 and UPP 16 i.e., above the platform design pressure. This maximum pressure may also be above the ultimate limit state for the pipeline, but it could be lower than that in some circumstances. In general it would also be set to be above pressures that could be controlled and safely contained using the subsea HIPPS, UPP HIPPS and UWP HIPPS. It is typically below the maximum allowable accumulated pressure for the platform(s) and hence below pressures that would cause failure of the equipment on the platforms. It could also be below the accidental limit state pressure for the pipeline. Additionally, it may sometimes be set to be below pressures that would cause damage to the equipment without a failure of the equipment, so that the equipment on the platforms could be used again with minimal inspection and/or testing in situations where the safe link device 62 was triggered and the installation is later re-started.

It will be understood that various designs could be applied to achieve the required functionality. The safe link device 62 is advantageously a physically triggered device, i.e. not reliant on sensors or actuators. This enhances the existing HIPPS since it means that the broader pressure protection system formed by the combination of the HIPPS and safe link device 62 uses two distinct mechanisms for release of pressure, one purely physical and one with sensors and electronic control. Thus, the safe link device 62 may be a structure in the pipeline that is designed to burst at a set pressure, such as a valve with a breakable pin that will fail at the required pressure, a rupture disc, or any other similar physical pressure relief mechanism that can be reliably designed to activate at the required pressure differential between the pipeline 18 and the external environment.

In this example the safe link device 62 comprises a rupture disc that is designed and calibrated based on the platform requirements and subsea conditions (e.g. temperature, pressure) in order to rupture at the threshold pressure. This rupture disc may generally be of similar design to known rupture discs that was used in topside installations. The safe link device 62 can be arranged so that the pipeline 18 vents to the environment when the safe link device 62 is triggered. Alternatively there may be systems in place to capture the contents of the pipeline 18 without hindering the pressure relief, such as a tank with a suitable arrangement of float valves to allow hydrocarbons to be captured to fill the tank as seawater exits the tank.

As noted above, the maximum pipeline pressure for activation of the safe link device 62 is set based on the pressure that can be permitted at the platform as well as on the subsea conditions at the location of the device 62. In the current example, where the safe link device 62 is used in combination with a subsea HIPPS, it is important to understand the

difference between the Ultimate Limit State (ULS) condition and the Accidental Limit State (ALS) condition for a pipeline system with a HIPPS, and the additional safety contribution from the safe link device 62.

An example; based on the following assumed pressure parameters:

- 5 • Wellhead shut-in pressure WHSIP = 700 barg(@subsea)
- Incidental Pressure with HIPPS IP = 400 barg (defined by HIPPS set points)
- Safe Link Failure Pressure SLFP = 430-450 barg

The WHSIP is the maximum pressure the pipeline system (i.e. pipeline and riser including attached components) can be exposed to, and without a High Integrity Pressure Protection System this is the pressure the pipeline system has to be designed for. The design is in general based on the incidental pressure, which is defined with an annual probability less than 10^{-2} (100-year value), and the incidental pressure is used as input for verification of the Ultimate Limit State (ULS) condition. However, for the case with a HIPPS we have to verify an additional scenario, i.e. HIPPS failure. The HIPPS failure scenario 15 should have low probability (defined by reliability requirements specified for the HIPPS), typically in the order of 10^{-5} – 10^{-4} , and can be verified based as an accidental limit state (ALS) condition. Consequently, there is a difference in the design of a pipeline system with a HIPPS and without a HIPPS, as set out below:

Burst failure design without a HIPPS (fully rated pipeline system):

- 20 • IP = WHSIP = 700 barg, and verified according to ULS condition.

Burst failure design with HIPPS:

- IP = 400 barg, verified as ULS condition.
- SLFP = 450 barg, verified as ALS condition

The use of a HIPPS will change the pressure probability density function for the 25 pipeline, which then results in the differences in design criteria. With the above example including HIPPS then the safe link device 62 would be arranged to release the pipeline pressure if it reached 450 barg and in practice this might give a maximum permitted pipeline pressure in the range 430-450 barg as noted above. Thus, the breaking element of the safe link device 62, which could be a rupture disc as set out above, would be designed to break 30 when the pressure reaches this range, taking account of the temperature and pressure conditions at the location of the safe link device 62.

The safe link device 62 will be located outside the platform safety zone. The safe link device 62 could include multiple parallel pressure relief systems such as by having multiple similar rupture discs. In this way there is redundancy in the design of the safe link device 62. 35 For example, if one rupture disc is degraded or damaged then the safe link device 62 should still operate to release over-pressure via another of the multiple rupture discs. For similar reasons it might be decided to install multiple safe link devices 62.

Injection of water for pressure support is planned for the reservoirs of both remote site A and remote site B via respective water injection pipelines 24, 26.

Produced fluid from remote site A and remote site B is mixed upstream of a subsea separator 30. The subsea separator 30 is a three phase separator operating at
5 approximately 40 bar initially. The temperature in the separator 30 is high (90°C) and good separation is expected.

Oil and water leaving the separator 30 is metered by a multiphase flow meter 32 and exported to a host 34. The receiving pressure at the host 34 will be kept at the same pressure as the subsea separator 30 to avoid flashing and multiphase flow in the export
10 pipeline or inlet heater at the host 34. The oil is only partly stabilized in the subsea separator 30, and further stabilization to pipeline export specification is assumed at the host 34.

The subsea separator 30 and pumps (not shown) are provided as a subsea separator and booster station (SSBS) 29, which is located as close to the UPP 16 as possible to minimize condensation and liquid traps in the gas piping from the separator 30 to
15 the UPP 16.

An umbilical 50 connects the UPP 16 to the host 34. The umbilical provides remote control of the operations of the UPP 16, as well as of the operations of the SPS 12, UWP 14 and SSBS 29 via secondary umbilicals 52, 54, 56. The secondary umbilicals 52, 54, 56 also supply any required power and chemicals required from the UPP 16 to the SPS 12, UWP 14
20 and SSBS 29.

Gas at 40 bar is delivered from the separator 30 to the UPP 16 topside inlet cooler 36 through a dedicated riser 38. The inlet cooler 36 comprises a seawater-cooled shell and tube heat exchanger. TEG is injected into the gas for hydrate inhibition before cooling the gas to 20°C in the seawater-cooled shell and tube inter stage cooler 36.

25 Condensed water and hydrocarbons are removed in a downstream scrubber 37. Liquid from the scrubber 37 flows by gravitation back down to the subsea separator 30 through a dedicated riser 40.

The gas from the scrubber 37 is then compressed to around 80 bar in a first stage compressor with a discharge temperature of around 80°C. The temperature should ideally
30 be as low as possible to reduce the amount of glycol required for dehydration.

The maximum cricondenbar pressure of the export gas is 110 barg. The cricondenbar is the pressure below which no liquid will be formed regardless of temperature. The cricondenbar is a property of the gas. The cricondenbar is determined by the conditions in the inlet scrubber 37.

35 The pressure in the scrubber 37 is determined by the pressure in the subsea separator 30. A low pressure in the separator 30 will reduce the flash gas in the export oil and is at some point in time required to realize the production profiles. The required

compression work and power consumption will however increase with a lower pressure. The separator 30 will operate at about 40 bar initially and the pressure will be reduced to 30 bar or even lower towards the end of the lifetime.

5 The selected UPP 16 design facilitates the unmanned processing of oil and gas in remote site B. A combination of subsea processing and topside processing on the UPP 16 can maximise operability and minimise capital and operational expenditure.

10 The UPP 16 has a steel jacket configuration. The jacket 46 is square with a spacing of 14 metres between the support columns 114. The jacket orientation is turned at 45° to the platform north to optimise weight versus size for the topside 48, so that the topside decks 48 are at 45° to the square of the jacket 46, as shown in Figure 3. By way of example, a possible UPP layout is shown in elevation in Figure 4, where the topside includes a spider deck 102, emergency shutdown valve (ESDV) deck 104, cellar deck 106, cellar mezzanine deck 108, process deck 110 and weather deck 112 respectively.

15 The UPP 16 uses a piled, four legged, symmetrically battered jacket 46 to support the topside 48. The topside 48 is 19.8m x 19.8m across the main structural span and its orientation is twisted compared to the jacket 46.

20 Umbilicals will be pulled into the platform 48 with a winch located on the weather deck 112 and a umbilical slot and reserved space are provided for this activity in centre of the platform 48. The slot and reserved space can be used for other purposes on the module deck areas once the pulling operation is completed.

The SSBS 29 is located on the seabed within the jacket 46. A subsea separator 30 is used instead of a topside solution on the UPP 16 because a topside solution would require an additional level on the UPP 16 due to the size and weight requirement.

25 The separator 30 is based on a symmetrical design with a central top inlet arrangement and top outlet arrangements at both ends combined with cyclones for gas polishing. Likewise oil and water outlets are at the bottom part inside and outside respective baffle-plates. Operation of the subsea separator 30 is performed using several distinct control loops.

30 The levels in the separator 30 are measured by a profiler level detector system. Water level control will adjust speed of the water injection pump and the level of oil will adjust speed of the export pump. The pressure in the subsea separator 30 is adjusted by the speed of the 1st stage compressor (suction pressure control). The control loops will be closed at the host 34 using fibre optic cables in umbilicals 50, 56.

35 The platform 14, 16 would be oriented based on the prevailing wind direction. For example, with the prevailing wind defined as north to south and west to east, the process equipment should be located on the east and southeast side of the platform to allow for good natural ventilation.

As noted above, the platform layout advantageously uses a twisted topside 48 as shown in Figure 3, with the topside decks 102, 104, 106, 108, 110, 112 rotated at 45° to the jacket 46. In this case the topside decks 102, 104, 106, 108, 110, 112 can be oriented with the cardinal points so that the sides of the square decks 102, 104, 106, 108, 110, 112 face north, south, east and west, and the jacket 46 is rotated at 45° relative to this, so that the corners of the jacket 46 face north, south, east and west.

The spider deck 102 is located at an elevation of 20m above sea level. The spider deck 102 will be provided with three personnel landings 122 located on the north corner of the jacket 46 when the Service Operation Vessel (SOV) is located on the north and east side of the UPP 16 and on the west corner of the jacket 46 when the SOV is located on the west side of the UPP 16. For the personnel landing 122 on the north corner a muster area is defined. The muster area can be located below the module and close to the north staircase to the decks above.

It is likely that the preferred side for a SOV is the east side of UPP 16 due to the prevailing wind direction. For this reason a laydown area 128 for material handling is located on this side. The laydown area 128 is 8 x 5m. From the laydown area 128 stairs are provided up to ESDV deck 104. Between the personnel landings and the laydown area 128, access and escape routes are provided.

The hang off arrangement for pipeline and risers that need 3D or 5D bend will be located on the spider deck 102. In addition it is likely that the umbilical and power cables should be hung off at this level and routed directly up to the termination panels.

The ESDV deck 104 is located 4m above the spider deck 102. Piping that enters the UPP 16 from the subsea are routed inside the jacket structure 46. For piping with an ESD valve, the ESD valve shall be located on ESDV deck 104. The pipeline specification will be terminated at the ESD valve. Piping including ESD valve should be designed according to ASME design code B31.3 Process piping. ESD valves for the 16" gas export and the 16" process line from the subsea separator will be the largest valves on this deck 104, and the valves will most likely set the deck height pending the arrangement for material handling. Termination cabinets for the umbilical (TUTU) will be located on this deck 104, on the north and close to the Umbilical slot. Two seawater pumps including strainers and hydraulic skid will be located on the west side of this deck together with a stacking area for seawater lift pump.

A temporary and removable open drain tank is located on the ESDV laydown area 130. The laydown area 130 is sized (5 x 2.5m) to allow for material handling when the drain tank is on the laydown area 130. The crane operator will have direct view and good accessibility with the weather deck crane 132.

The cellar deck 106 is located 6m above the ESDV deck 104. Access to cellar deck 106 is through a stair case on the north side from both the process deck 110 above and the ESDV deck 104 below. The stair case is in connection with the cellar deck laydown area 130. The south stair from the above and below area will land close to the bridge. From a north laydown area to a bridge 136 on the south side is a main escape route connecting the staircases through the platform decks 102, 104, 106, 108, 110, 112. The bridge 136 is 75m long and will tie the UPP 16 to the UWP 14.

The cellar deck mezzanine deck 108 is 4.6 m above the cellar deck 106 in this example. Access to the deck below and the deck above is arranged for by the north and south staircase, in addition to the internal south stair. A local instrument room with natural ventilation is on the south part of this mezzanine deck 108. Access can be provided from a stair on the south end or through the stair on the north east corner of the room.

Above the cellar deck 106 and cellar deck mezzanine 108 is a process deck 110. In this example the process deck 110 is located 9m above the cellar deck 106. Access to the deck below is arranged for by the north and south staircase. Access to the weather deck 112 is arranged on the east and west side.

The weather deck 112 is 8m above the process deck 110 in this example. From this deck the access and escape possibilities are through stairs case on the east and west side of the installation and down to the cellar deck 106. The main equipment on the weather deck 112 is an intercooler heat exchanger and inlet gas heat exchangers. Dual heat exchangers will be stacked on top of each other on the south west deck area. A package with chemical tanks and pump may be required pending the supply of chemicals from OFC through the umbilical.

The vent stack 142 is located on the south –east corner due to the prevailing wind direction and to be close to process equipment for shortest possible pipe routing. Relief valves for the vent line will be located close to the vent stack 142. In this example the size of the stack is 1.5 x 1.5 x 10m. The vent stack 142 is used for cold venting during certain procedures, and it is not used for emergency depressurisation in the event of a fire or other emergency. The vent stack 142 can be used for pressure relief of methane gas through cold vent 142 during barrier testing and maintenance operations that require pressure relief. It will be appreciated that there is no flare for this platform 16, which is a significant difference to the conventional arrangement. In the event of a fire there is no emergency depressurisation at the platform and instead the piping and equipment on the platform 16 is isolated from wells and larger volumes of hydrocarbons in connected external piping by valves, then left at operating pressure. The pressure will be released by the safe link device 62 if it exceeds the burst pressure of the safe link device 62, and the HIPPS for the UPP 16 may also act to control the pressure under some circumstances. As discussed above this generates an

added risk in relation to escalation of the fire, but this risk can be managed by restricting the size of the platform 16 and hence minimising the evacuation time, and also by adding passive fire protection as described below.

5 The platform crane 132 is located on the north east corner for good access to all the laydown areas 128, 130 provided on the various decks below. This has an 18 m reach and the access to the laydown areas 128, 130 as well as to the SOV is aided by the twisted topside arrangement of the platform 16.

10 Goods lifted by the SOV to the spider deck laydown area 128 can be picked up by the platform crane 132 and moved to a local laydown area 130. An area on the weather deck 112 can be reserved for helicopter drop, although it will be appreciated that the platform design does not allow for a heli-deck.

15 It will be appreciated that the exact layout for the platforms in terms of the decks that are present and the equipment that is used can vary. The layout of the installation can also vary. The invention is as defined by the claims and the above discussion is an example of one implementation of a safe link device 62.

CLAIMS:

1. A method for pressure protection of an offshore platform of an oil and gas installation, the offshore platform being connected to source of hydrocarbons via a pipeline,
5 the method comprising:

using a safe link device at the pipeline;

wherein the safe link device is located subsea and outside of the safety zone of the platform;

protecting the platform via a subsea High Integrity Pressure Protection System (HIPPS) for the platform 14, 16 and/or the pipeline 18; and

wherein the safe link device is arranged to activate to release pressure from the pipeline when the pressure exceeds a preset threshold that is above the design pressure for the platform.

2. A method as claimed in claim 1, wherein the HIPPS is arranged to control the pressure to a lower level than the preset threshold for activation of the safe link device.

3. A method as claimed in claim 1 or 2, wherein the preset threshold is above the normal operating pressure for the platform and above the ultimate limit state pressure for the pipeline.

4. A method as claimed in claim 1, 2 or 3, wherein the preset threshold is below the maximum allowable accumulated pressure for the platforms and/or below the accidental limit state pressure for the pipeline.

5. A method as claimed in any preceding claim, wherein the safe link device is a physically triggered device including at least one of: a structure in the pipeline that is designed to burst at a set pressure, a valve with a breakable pin that will fail at the required pressure, or a rupture disc.

6. A method as claimed in any preceding claim, wherein the safe link device comprises a rupture disc that will break and release the pressure from the pipeline when the pipeline pressure exceeds the preset threshold.

7. A method as claimed in any preceding claim, wherein the safe link device is located 500m or more from the platform.

8. A method as claimed in any preceding claim, comprising using multiple safe link devices for redundancy and/or wherein the safe link device comprises multiple pressure activated mechanisms for redundancy.

5 9. A method as claimed in any preceding claim, wherein the preset threshold is in the range 430-450 barg.

10 10. A method as claimed in any preceding claim, comprising arranging the platform such that there is no mechanism for emergency depressurisation of a hydrocarbon inventory of the platform in the event of a fire or other emergency that causes an over-pressure.

15 11. A method as claimed in any preceding claim, wherein the platform is an unmanned platform with no permanent personnel.

20 12. A method as claimed in any preceding claim, wherein the platform is an unmanned platform and has no provision of facilities for personnel to stay on the platform, for example there may be no shelters for personnel, no toilet facilities, no drinking water, no personnel operated communications equipment, no heli-deck and/or no lifeboat.

25 13. A method as claimed in any preceding claim, wherein the platform is an unmanned platform and requires personnel to be present for fewer than 10,000 maintenance hours per year.

30 14. A pressure protection system for a platform of an offshore oil and gas installation, wherein the platform is connected to a source of hydrocarbons via a pipeline, the pressure protection system comprising:

a safe link device at the pipeline;

35 wherein the safe link device is located subsea and outside of the safety zone of the platform;

a subsea High Integrity Pressure Protection System (HIPPS) at the platform and/or the pipeline for protecting the platform; and

wherein the safe link device is arranged to activate to release pressure from the pipeline when the pressure exceeds a preset threshold that is above the design pressure for the platform.

15. A pressure protection system as claimed in claim 14, wherein the HIPPS is arranged to control the pressure to a lower level than the preset threshold for activation of the safe link device.

5 16. A pressure protection system as claimed in claim 14 or 15, wherein the preset threshold is above the normal operating pressure for the platform and above the ultimate limit state pressure for the pipeline.

10 17. A pressure protection system as claimed in claim 14, 15 or 16, wherein the preset threshold is below maximum allowable accumulated pressure for the platforms and/or below the accidental limit state pressure for the pipeline.

15 18. A pressure protection system as claimed in any of claims 14 to 17, wherein the safe link device is a physically triggered device including at least one of: a structure in the pipeline that is designed to burst at a set pressure, a valve with a breakable pin that will fail at the required pressure, or a rupture disc.

20 19. A pressure protection system as claimed in any of claims 14 to 18, wherein the safe link device comprises a rupture disc that will break and release the pressure from the pipeline when the pipeline pressure exceeds the preset threshold.

20. A pressure protection system as claimed in any of claims 16 to 19, wherein the safe link device is located 500m or more from the platform.

25 21. A pressure protection system as claimed in any of claims 16 to 20, comprising multiple safe link devices for redundancy and/or wherein the safe link device comprises multiple pressure activated mechanisms for redundancy.

30 22. A pressure protection system as claimed in any of claims 14 to 21, wherein the preset threshold is in the range 430-450 barg.

35 23. A pressure protection system as claimed in any of claims 14 to 22, wherein the platform has no mechanism for emergency depressurisation of a hydrocarbon inventory of the platform in the event of a fire or other emergency that causes an over-pressure.

23. A platform as claimed in any of claims 14 to 23, wherein the platform is an unmanned platform with no permanent personnel, wherein the unmanned platform has no

provision of facilities for personnel to stay on the platform, for example there may be no shelters for personnel, no toilet facilities, no drinking water, no personnel operated communications equipment, no heli-deck and/or no lifeboat; and/or wherein the unmanned platform is arranged such that personnel are required to be present for fewer than 10,000

5 maintenance hours per year.

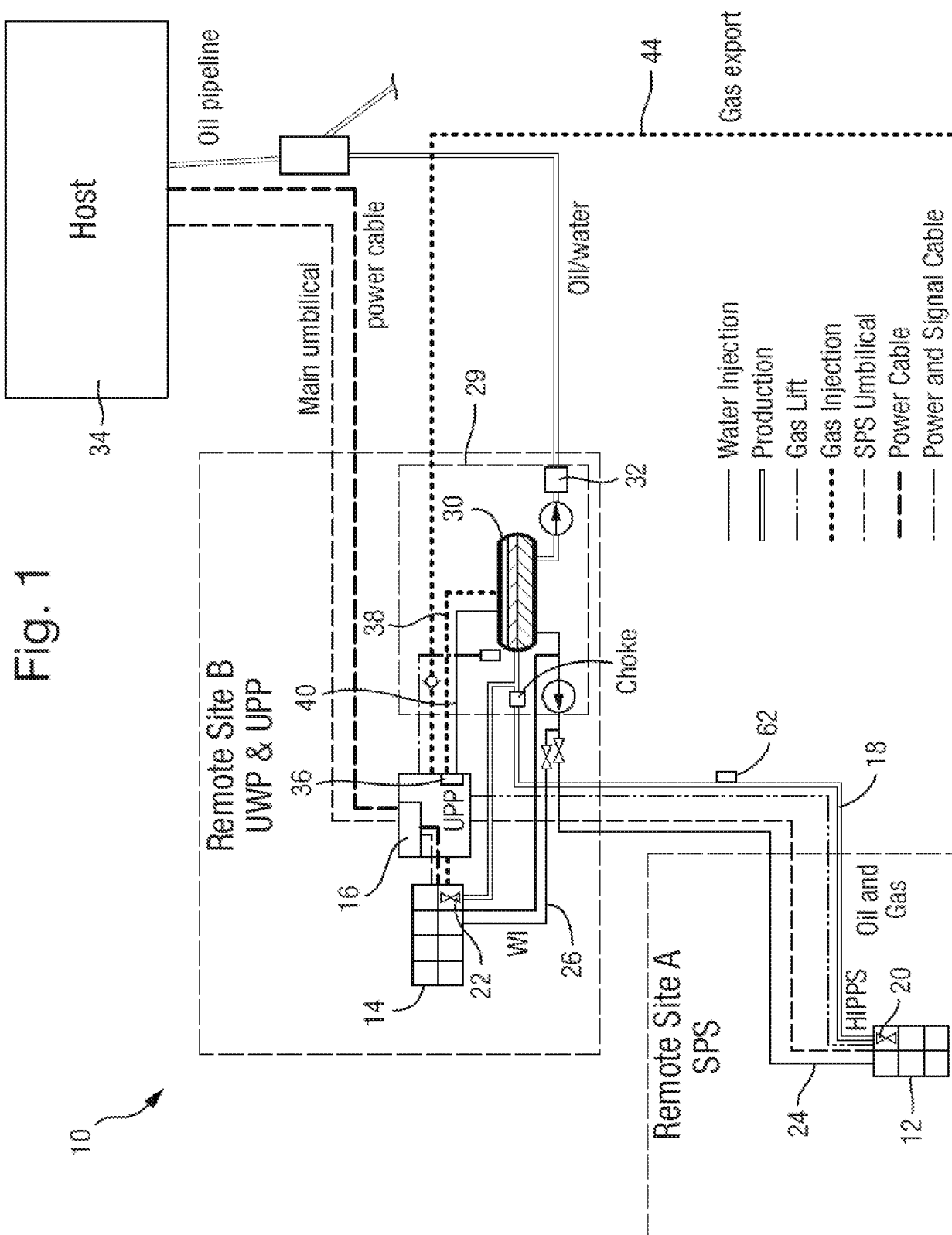


Fig. 2

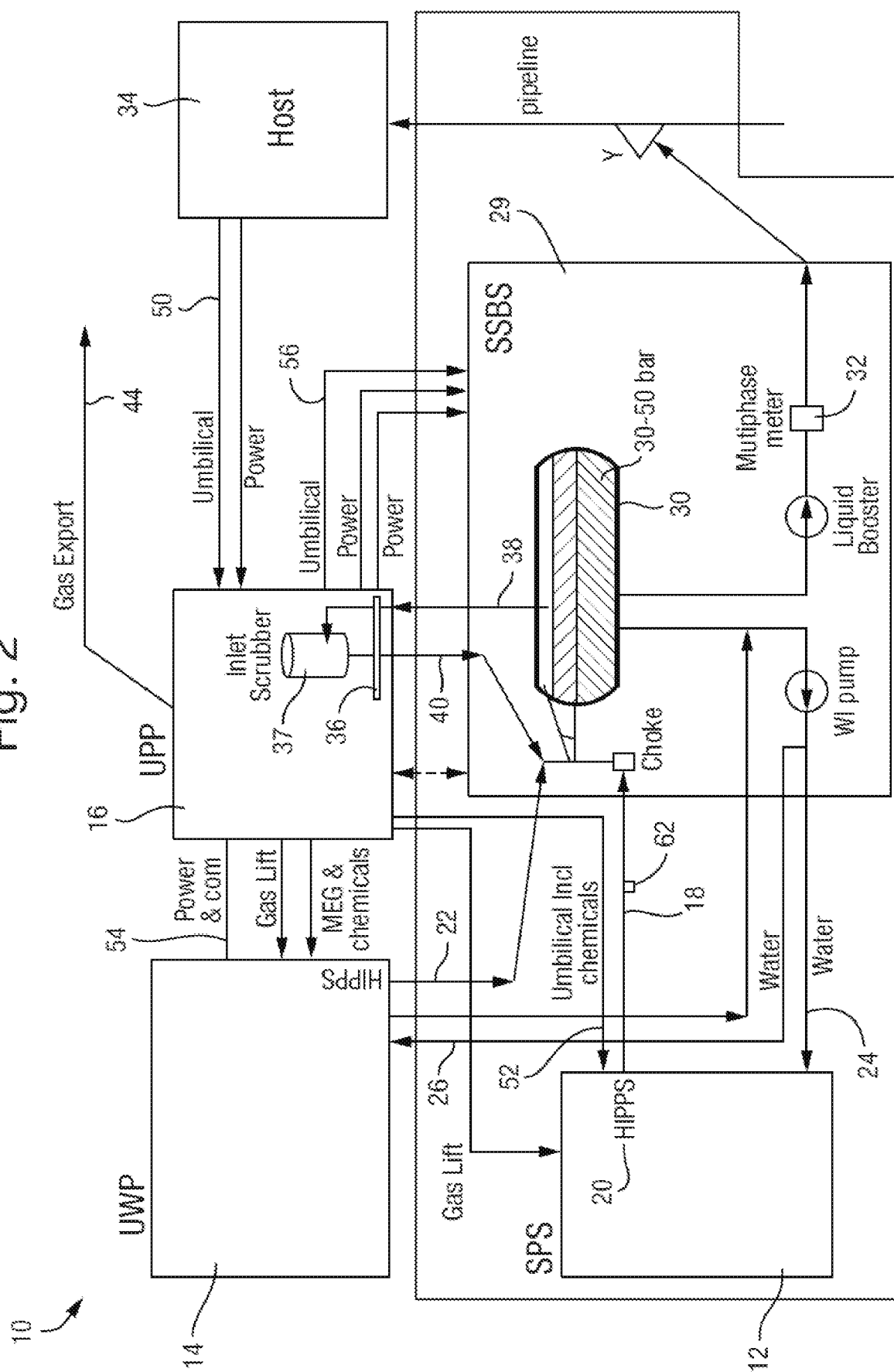


Fig. 4

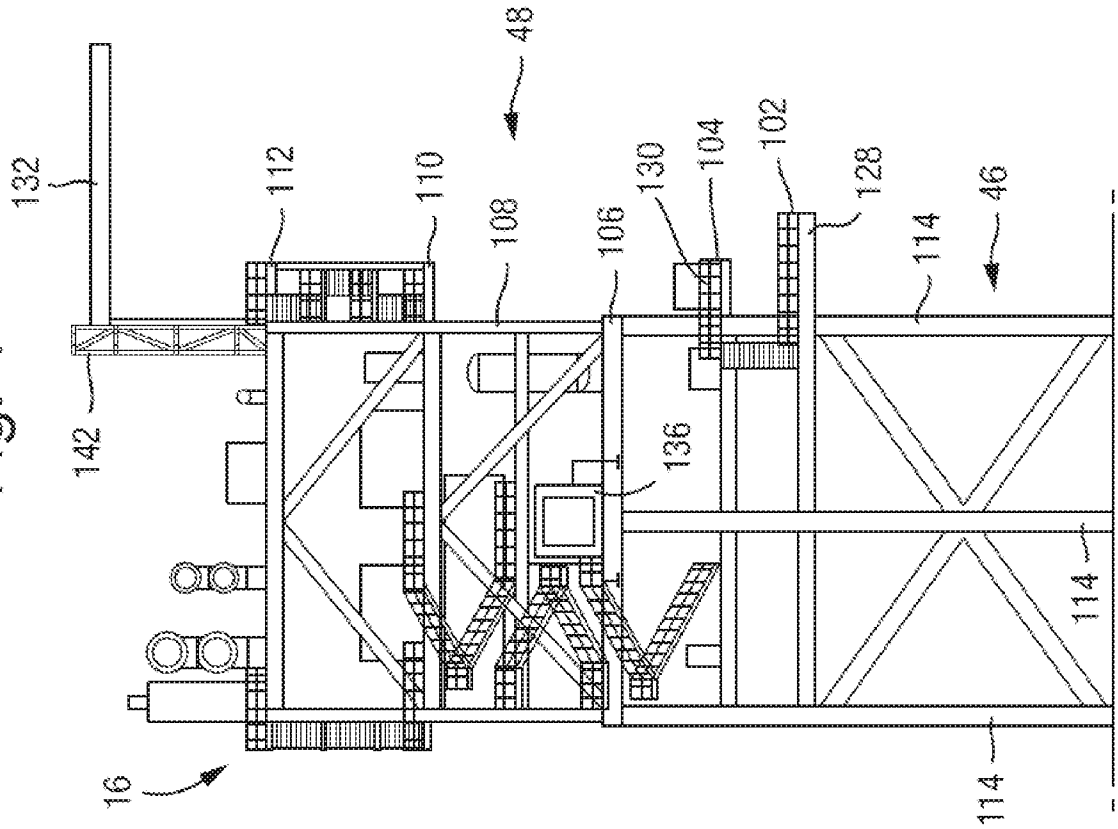
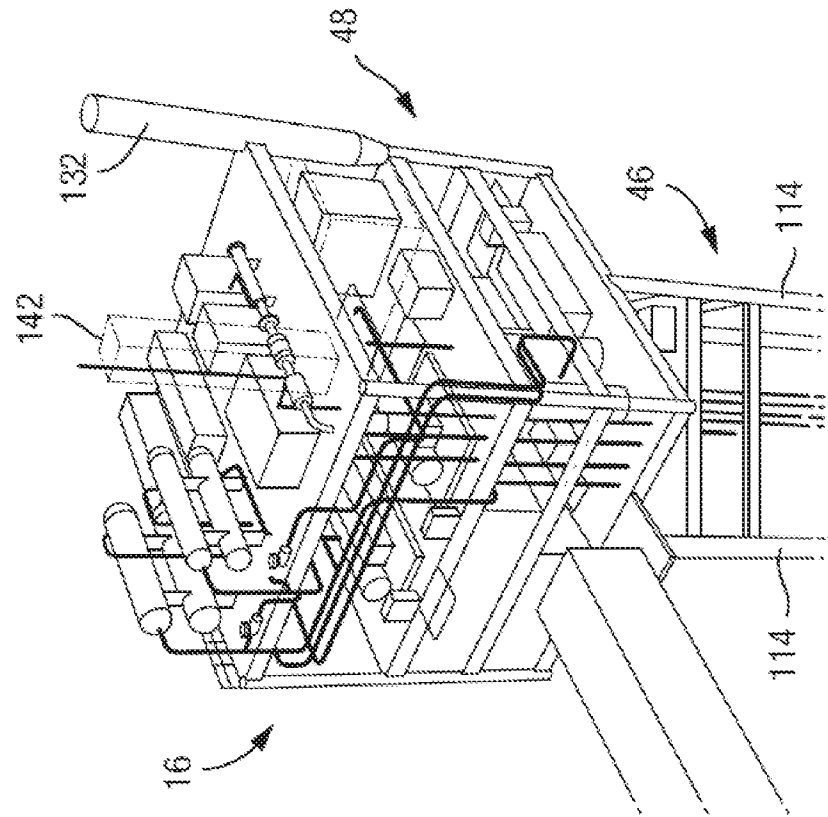


Fig. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2018/050022

A. CLASSIFICATION OF SUBJECT MATTER E21B 43/00 (2006.01), F16K 17/00 (2006.01), F16L 55/00 (2006.01) 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, F16L, F16K Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, NO, SE, FI: Classes as above. Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPODOC, WPI, FULL TEXT: ENGLISH, PATGRANSK		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2592318 A1 (VETCO GRAY CONTROLS LIMITED) 2013.05.15 Abstract, Fig. 1-2, [0002], [0003], [0011]	1-24
A	US 2012/0318529 A1 (HERROLD et al.) 2012.12.20 Abstract, Fig. 1, [0005], [0021] - [0026]	1-24
A	US 2013/0327535 A1 (LAMISON) 2013.12.12 Abstract, Fig. 1, [0005], [0013], [0018] - [0020], [0040] - [0042]	1-24
☐ Further documents are listed in the continuation of Box C. ☒ 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 14/03/2018		Date of mailing of the international search report 15/03/2018
Name and mailing address of the ISA Nordic Patent Institute Helgeshøj Allé 81 DK - 2630 Taastrup, Denmark. Facsimile No. + 45 43 50 80 08		Authorized officer Martin N. Wikheim Telephone No. +47 22 38 75 13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/NO2018/050022

Patent document cited in search report / Publication date	Patent family member(s) / Publication date
EP 2592318 A1 2013.05.15	NONE
US 2012318529 A1 2012.12.20	WO 2012151113 A1 2012.11.08
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