is a need for an efficient system to safely convert existing diverter infrastructure into an MPD-capable closed loop system utilizing a more reliable sealing technology than prior arts within the diverter. It is preferred that the inventive system and method has compatibility with common diverter models used offshore. For new build rigs, the configuration described here can be used to replace the existing atmospheric diverter design with this improved system and method.

~~It is an object~~Embodiments of the system described in this application ~~to~~ provide an alternative, possibly more cost effective, diverter system which is capable of operating at the pressures experienced in MPD, which may be simpler to install and which does not require the need to change the rig's riser space out, and therefore may more readily be integrated into existing systems.

According to a first aspect of the present invention, there is provided a diverter for diverting a fluid from a riser in a drilling system, the diverter including: a diverter support housing including, a suspension structure configured so that the diverter support housing is suspendable from a drilling rig, and a main passage arranged to extend from an uppermost end of the diverter support housing to a lowermost end of the diverter support housing, the main passage being configured to have a drill string extend therethrough; a diverter housing arranged in the main passage; an annular packer element mounted within the diverter housing; an actuator mounted within the diverter housing, the actuator being configured to force the annular packer element into a sealing engagement with the drill string; a tubular sealing element; a seal locking mechanism configured to retain the tubular sealing element in the diverter housing adjacent to the annular packer element, the seal locking mechanism being configured to be retractable so as to move between an operative position in which the seal locking mechanism extends from the diverter housing into the main passage, and an inoperative position in which the seal locking mechanism is retracted into the diverter housing so that it no longer extends into the main passage; and a fluid pressure operating system configured so that a supply of a pressurised fluid thereto moves the seal locking mechanism between the operative position and the inoperative position.

According to a second aspect of the present invention, there is provided a method of operating a drilling system, the drilling system including: a riser; a drill string

extending within the riser; a pressure vessel; a source of a pressurised gas; a pressure sensor; and a main flow line configured to extend from the riser to the pressure vessel, wherein, the pressure vessel comprises, a liquid inlet port connected to the main flow line, a gas inlet port connected to the source of the pressurised gas, a liquid outlet port arranged in a lowermost portion of the pressure vessel, a liquid pressure control valve configured to control a flow of a liquid out of the vessel via the liquid outlet port, a gas outlet port located in an uppermost portion of the pressure vessel, a gas pressure control valve configured to control a flow of the pressurized gas out of the pressure vessel via the gas outlet port, and a secondary pressure control valve arranged in the main flow line, the method including: closing the secondary pressure control valve so as to increase an extent to which the secondary pressure control valve restricts the flow of the fluid along the main flow line; and closing the gas pressure control valve so as to increase an extent to which the gas pressure control valve restricts the flow of the pressurized gas out of the pressure vessel via the gas outlet port, using an output of the pressure sensor to determine when a pressure in the pressure vessel is approximately equal to a pressure in the main flow line upstream of the secondary pressure control valve; and opening the secondary pressure control valve when the pressure in the pressure vessel is generally equal to the pressure in the main flow line.

According to a third aspect of the present invention, there is provided a diverter for diverting a fluid from a riser in a drilling system, the diverter including: a diverter support housing including, a suspension structure configured so that the diverter support housing is suspendable from a drilling rig, and a main passage arranged to extend from an uppermost end of the diverter support housing to a lowermost end of the diverter support housing, the main passage being configured to have a drill string extend therethrough; a diverter housing arranged in the main passage; an annular packer element mounted within the diverter housing; an actuator mounted within the diverter housing, the actuator being configured to force the annular packer element into a sealing engagement with the drill string; a tubular sealing element; and a seal locking mechanism configured to retain the tubular sealing element in the diverter housing adjacent to the annular packer element, wherein, the actuator comprises a piston which is configured to move substantially parallel to a longitudinal axis of the main passage and to apply a pressure on the annular packer element so as to force the annular packer element inwards, the annular packer element thereby contacting

and applying a radial pressure on an external surface of the tubular sealing element, thereby forcing the tubular sealing element to contact the drill string.

~~According to a first aspect of the invention we provide~~Disclosed herein is a drilling system including a riser, a pressure vessel, a source of pressurised gas, and a main flow line which extends from the riser to the pressure vessel, the pressure vessel having a liquid inlet port connected to the main flow line, a gas inlet port connected to the source of pressurised gas, a liquid outlet port located in a lowermost portion of the pressure vessel, and a gas outlet port located in an uppermost portion of the pressure vessel.

The gas inlet port may be provided in an uppermost portion of the pressure vessel.

The system preferably also includes a liquid pressure control valve which is operable to control the flow of liquid out of the pressure vessel via the liquid outlet port.

The system preferably also includes a gas pressure control valve which is operable to control the flow of gas out of the pressure vessel via the gas outlet port.

The system may also include a mud gas separator which has a liquid inlet port to which the liquid outlet port of the pressure vessel is connected by means of a liquid flow line. In this case the liquid pressure control valve may be provided in the liquid flow line.

Where the system includes a mud gas separator, the mud gas separator may have a gas inlet port to which the gas outlet port of the pressure vessel is connected by means of a vent line. In this case the gas pressure control valve may be provided in the vent line.

A valve may be provided in a line connecting the source of pressurised gas to the gas inlet port of the pressure vessel.

A secondary pressure control valve may be provided in the main flow line.

The main flow line may be connected to the riser via a diverter.

The diverter may include a diverter assembly which is operable to close around a drill string extending down the riser to contain pressure in the annulus of the riser around

the drill string. In this case, preferably the diverter closes around the drill string above the connection to the main flow line. The diverter assembly is preferably operable to close around a drill string extending down the riser to contain pressure in the annulus of the riser around the drill string whilst allowing the drill string to rotate about its longitudinal axis.

The diverter assembly may be mounted in a diverter support housing which is adapted, in use, to be suspended from a rig floor.

A slip joint may be provided in the riser below the connection to the main flow line.

The source of pressurised gas may comprise a bottle of compressed nitrogen.

The system may further include a pressure sensor which is operable to provide an output indicative of the pressure of the gas in the uppermost region of the pressure vessel.

The system may further include a liquid level sensor which is operable to provide an output indicative of the level of the liquid in the pressure vessel.

~~According to a second aspect of the invention we provide~~Disclosed herein is a method of operating a drilling system including a riser, a pressure vessel, a source of pressurised gas, and a main flow line which extends from the riser to the pressure vessel, the pressure vessel having a liquid inlet port connected to the main flow line, a gas inlet port connected to the source of pressurised gas, a liquid outlet port located in a lowermost portion of the pressure vessel, a liquid pressure control valve which is operable to control the flow of liquid out of the vessel via the liquid outlet port, a gas outlet port located in an uppermost portion of the pressure vessel, and a gas pressure control valve which is operable to control the flow of gas out of the vessel via the gas outlet port, wherein the method includes the steps of operating one or both of the liquid pressure control valve and gas pressure control valve to control the pressure in the riser.

The method may include the steps of opening both the gas pressure control valve and liquid pressure control valve so as to decrease the degree to which the valves restrict flow of fluid out of the vessel in order to decrease the pressure in the riser, or closing both the gas pressure control valve and liquid pressure control valve so as to

increase the degree to which the valves restrict flow of fluid out of the vessel in order to increase the pressure in the riser.

The system may also include a mud gas separator which has a liquid inlet port to which the liquid outlet port of the pressure vessel is connected by means of a liquid flow line. In this case the liquid pressure control valve may be provided in the liquid flow line.

Where the system includes a mud gas separator, the mud gas separator may have a gas inlet port to which the gas outlet port of the pressure vessel is connected by means of a vent line. In this case the gas pressure control valve may be provided in the vent line.

A secondary pressure control valve may be provided in the main flow line, and the method may include the steps of operating the secondary pressure control valve to control the pressure in the riser and operating the liquid pressure control valve and/or the gas pressure control valve to bring the pressure in the pressure vessel to a desired level, and then opening the secondary pressure control valve to decrease the extent to which it restricts the flow of fluid along the main flow line, before operating the liquid pressure control valve and/or gas pressure control valve to control the pressure in the riser.

The system may include a gas supply valve which controls the flow of gas from the source of pressurised gas into the pressure vessel, and method may further include the step of opening the gas supply valve after closing the gas pressure control valve and the secondary pressure control valve.

The main flow line may be connected to the riser via a diverter.

The diverter may include a diverter assembly, and the method may include operating the diverter assembly to close around a drill string extending down the riser to contain pressure in the annulus of the riser around the drill string. Preferably this is done prior to operating the gas pressure control valve and/or liquid pressure control valve, or, where provided, the secondary pressure control valve. In this case, preferably the diverter closes around the drill string above the connection to the main flow line. The diverter assembly is preferably operable to close around a drill string

extending down the riser to contain pressure in the annulus of the riser around the drill string whilst allowing the drill string to rotate about its longitudinal axis.

The diverter assembly may be mounted in a diverter support housing which is adapted, in use, to be suspended from a rig floor.

A slip joint may be provided in the riser below the connection to the main flow line.

The source of pressurised gas may comprise a bottle of compressed nitrogen.

The system may further include a pressure sensor which is operable to provide an output indicative of the pressure of the gas in the uppermost region of the pressure vessel, and the method may include using the output of the pressure sensor to determine how to operate the gas pressure control valve and/or the liquid pressure control valve.

The system may further include a liquid level sensor which is operable to provide an output indicative of the level of the liquid in the pressure vessel, and the method may include using the output of the gas pressure sensor to determine how to operate the liquid pressure control valve.

~~According to a third aspect of the invention we provide~~Disclosed herein is a method of operating a drilling system including a riser, a pressure vessel, a source of pressurised gas, and a main flow line which extends from the riser to the pressure vessel, the pressure vessel having a liquid inlet port connected to the main flow line, a gas inlet port connected to the source of pressurised gas, a liquid outlet port located in a lowermost portion of the pressure vessel, a liquid pressure control valve which is operable to control the flow of liquid out of the vessel via the liquid outlet port, a gas outlet port located in an uppermost portion of the pressure vessel, a gas pressure control valve which is operable to control the flow of gas out of the vessel via the gas outlet port, and a secondary pressure control valve which is located in the main flow line, wherein the method includes the steps of closing the secondary pressure control valve so as to increase the extent to which it restricts flow of fluid along the main flow line, and closing the gas pressure control valve so as to increase the extent to which it restricts flow of fluid out of the pressure vessel via the gas outlet port, using the output of the pressure sensor to determine when the pressure in the pressure vessel is approximately equal to the pressure in the main flow line upstream

of the secondary pressure control valve, and opening the secondary pressure control valve when the pressure in the pressure vessel is generally equal to the pressure in the main flow line.

The system may include a gas supply valve which controls the flow of gas from the source of pressurised gas into the pressure vessel, and method may further include the step of opening the gas supply valve after closing the gas pressure control valve and the secondary pressure control valve.

The method may include the steps of operating the liquid pressure control valve and / or the gas pressure control valve to control the pressure in the riser.

The method may include the steps of opening both the gas pressure control valve and liquid pressure control valve so as to decrease the degree to which the valves restrict flow of fluid out of the gas pressure vessel in order to decrease the pressure in the riser, or closing both the gas pressure control valve and liquid pressure control valve so as to increase the degree to which the valves restrict flow of fluid out of the pressure vessel in order to increase the pressure in the riser.

The system may also include a mud gas separator which has a liquid inlet port to which the liquid outlet port of the pressure vessel is connected by means of a liquid flow line. In this case the liquid pressure control valve may be provided in the liquid flow line.

Where the system includes a mud gas separator, the mud gas separator may have a gas inlet port to which the gas outlet port of the pressure vessel is connected by means of a vent line. In this case the gas pressure control valve may be provided in the vent line.

The main flow line may be connected to the riser via a diverter.

The diverter may include a diverter assembly, and the method may include operating the diverter assembly to close around a drill string extending down the riser to contain pressure in the annulus of the riser around the drill string. Preferably this is done prior to operating the gas pressure control valve and liquid pressure control valve. In this case, preferably the diverter closes around the drill string above the connection to the main flow line. The diverter assembly is preferably operable to

close around a drill string extending down the riser to contain pressure in the annulus of the riser around the drill string whilst allowing the drill string to rotate about its longitudinal axis.

The diverter assembly may be mounted in a diverter support housing which is adapted, in use, to be suspended from a rig floor.

A slip joint may be provided in the riser below the connection to the main flow line.

The source of pressurised gas may comprise a bottle of compressed nitrogen.

The system may further include a pressure sensor which is operable to provide an output indicative of the pressure of the gas in the uppermost region of the pressure vessel, and the method may include using the output of the pressure sensor to determine how to operate the gas pressure control valve and/or the liquid pressure control valve.

The system may further include a liquid level sensor which is operable to provide an output indicative of the level of the liquid in the pressure vessel, and the method may include using the output of the pressure sensor to determine how to operate the liquid pressure control valve.

~~According to a fourth aspect of the invention we provide~~Disclosed herein is a diverter for diverting fluid from a riser in a drilling system, the diverter comprising a diverter support housing having a suspension structure by means of which the diverter support housing may be suspended from a drilling rig, a main passage which extends from an uppermost end of the diverter support housing to a lowermost end, a diverter housing which is located in the main passage of the diverter support housing, there being mounted within the diverter housing an annular packer element and actuator which is operable to force the annular packer into sealing engagement with a drill string extending through the main passage of the diverter support housing, the diverter being further provided with a seal locking mechanism which is operable to retain a tubular sealing element in the diverter housing adjacent to the packer element.

Advantageously, the locking mechanism is retractable, i.e. movable between an operative position in which it extends from the diverter housing into the main

passage, and an inoperative position, in which it is retracted into the diverter housing so that it no longer extends into the main passage. In this case, the diverter may include a fluid pressure operating system which is configured such that movement of the locking mechanism between the operative and inoperative position occurs by means of the supply of pressurised fluid to the fluid pressure operating system.

The locking mechanism may comprise a first locking element and a second locking element are spaced longitudinally along the main passage so that a tubular sealing element may be retained between the first locking element and second locking element when they are in their operative positions.

The diverter support housing may further include a landing shoulder which extends into the main passage at a lowermost end of the diverter support housing, the diverter housing engaging with the landing shoulder so that the landing shoulder prevents further movement of the diverter housing in a first direction along the main passage.

The diverter support housing and diverter housing are preferably provided with a side passage which extends from the exterior of the diverter support housing into the main passage.

The diverter may be provided with a seal which provides a fluid tight seal between the interior face of the diverter support housing and an exterior surface of the diverter housing. Where the diverter support housing and diverter housing are provided with a side passage, the diverter preferably includes two such seals, the side passage being located between the two seals so that the seals substantially prevent leakage of fluid from the side port between the diverter support housing and the diverter housing.

The seals are preferably circular and located in a circular groove around the exterior surface of the diverter housing.

The actuator may comprise a piston which is movable generally parallel to the longitudinal axis of the main passage to urge the packer element into sealing engagement with a drill string extending along the main passage.

The diverter may be provided with a further locking mechanism whereby the diverter housing may be secured in the diverter support housing. In this case, the further locking mechanism may comprise a hydraulically operable locking element which is movable into an operative position in which it extends from the diverter support housing into a corresponding groove or aperture in the diverter housing.

~~According to a fifth aspect of the invention we provide~~Disclosed herein is a diverter assembly comprising a diverter for diverting fluid from a riser in a drilling system, and a control apparatus, the diverter comprising a diverter support housing having a suspension structure by means of which the diverter support housing may be suspended from a drilling rig, a main passage which extends from an uppermost end of the diverter support housing to a lowermost end, a diverter housing which is located in the main passage of the diverter support housing, there being mounted within the diverter housing an annular packer element and actuator, the actuator dividing the interior of the diverter housing into two chambers, namely an open chamber and a close chamber, substantially preventing flow of fluid between the two chambers, and being movable, by means of the supply of pressurised fluid to the close chamber, to urge the packer element into sealing engagement with a drill pipe extending through the diverter, the control apparatus including a close line which extends from the exterior of the housing to the close chamber, and a source of pressurised fluid which is connected to the close line, wherein the source of pressurised fluid is located adjacent to the diverter housing.

Preferably the source of pressurised fluid is less than 15 foot from the close chamber

The source of pressurised fluid preferably comprises at least one accumulator.

Advantageously, the control apparatus further comprises a close control valve which is located in the close line between the source of pressurised fluid and the close chamber, the close control valve being movable between an open position in which flow of fluid from the source of pressurised fluid to the close chamber is permitted, and a closed position in which flow of fluid from the source of pressurised fluid to the close chamber is substantially prevented.

The source of pressurised fluid is advantageously so close to the housing that the time between opening the close control valve and closing of the blow out preventer is

3 seconds or less where a drill string is present in the blowout preventer or 5 seconds or less where there is no drill string present in the blowout preventer.

The close control valve is preferably electrically or electronically operable. In this case, the control valve may move from the closed to position to the open position when supplied with electrical power.

Supply of electrical power to the close control valve may be controlled by an electronic control unit which is remote from the blow out preventer and control apparatus.

The control apparatus may further comprise a pump which has an inlet which draws fluid from a fluid reservoir and an outlet which is connected to the close line.

The control apparatus may further comprise an open line which extends from the exterior of the housing to the open chamber.

The pump may be connected to the open line in addition to the close line. In this case, the control apparatus advantageously includes a further valve which is movable from an open configuration in which flow of fluid from the pump to the close line is permitted whilst flow of fluid from the pump to the open line is substantially prevented, and a closed configuration in which flow of fluid from the pump to the open line is permitted whilst flow of fluid from the pump to the close line is substantially prevented.

The open line may be provided with an exhaust valve which is located adjacent to the housing, and which is movable between a first position in which flow of fluid along the open line into the open chamber is permitted, and a second position in which the open line is substantially blocked upstream of the exhaust valve relative to the open chamber, and the open chamber is connected to a low pressure region.

The low pressure region may be the atmosphere at the exterior of the housing.

The low pressure region may comprise an exhaust conduit which has a greater cross-sectional area than the open line, and which is connected to a fluid reservoir.

The close line may be at least 2 inches in diameter.

The open line may be at least 2 inches in diameter.

~~According to a sixth aspect of the invention we provide A~~Disclosed herein is a diverter assembly comprising a diverter for diverting fluid from a riser in a drilling system, and a control apparatus, the diverter comprising a diverter support housing having a suspension structure by means of which the diverter support housing may be suspended from a drilling rig, a main passage which extends from an uppermost end of the diverter support housing to a lowermost end, a diverter housing which is located in the main passage of the diverter support housing, there being mounted within the diverter housing an annular packer element and actuator, the actuator dividing the interior of the diverter housing into two chambers, namely an open chamber and a close chamber, substantially preventing flow of fluid between the two chambers, and being movable, by means of the supply of pressurised fluid to the close chamber, to urge the sealing element into sealing engagement with a drill pipe extending through the diverter, wherein the control apparatus includes an exhaust valve which is located adjacent to the housing, and which is movable between a first position in which flow of fluid along the open line into the open chamber is permitted, and a second position in which the open line is substantially blocked upstream of the exhaust valve relative to the open chamber, and the open chamber is connected to a low pressure region.

The low pressure region may be the atmosphere at the exterior of the housing.

The low pressure region may comprise an exhaust conduit which has a greater cross-sectional area than the open line, and which is connected to a fluid reservoir.

~~The diverter assembly according to the sixth aspect of the invention may have any of the features of the diverter assembly according to the fifth aspect of the invention.~~