

In the case of adding a further conventional control mechanism for devices, such as a valve, or sensor downhole; the inventors of the present invention also note limitations since, in the event of a blow-out, the ability to function
 5 these devices may be lost due to the inability to fluctuate pressure to control pressure activated devices, or due to the loss of control lines.

Thus it is difficult for a skilled person to design a further safety system which can practically add to the safety systems already provided in oil wells.

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An object of the present invention is to mitigate problems with the prior art, and preferably to improve the safety of wells.

According to a first aspect of the present invention there is provided a safety
 15 mechanism comprising:

an obstructing member moveable between, normally from, a first position where fluid flow is permitted, and, normally to, a second position where fluid flow is restricted;

a movement mechanism;

20 and a wireless receiver normally a transceiver, adapted to receive, and ~~normally transmit,~~ a wireless signal;

wherein the movement mechanism is operable to move the obstructing member from one of the first and second positions to the other of the first and second positions in response to a change in the signal being received by the

25 wireless transceiver;

wherein the movement mechanism is adapted to move the obstructing member from one of the first and second positions to the other of the first and second positions automatically in response to at least one level of a parameter detected by a sensor; and wherein the level of the parameter at which the
 30 safety mechanism is adapted to move the obstructing member to/from the first position from/to the second position is variable by an operator.

The obstructing member can in certain embodiments therefore start at either the first or second positions.

the same wells as a BOP or a wellhead, tree, or well-cap and may be provided in addition to a conventional subsurface safety valve.

Typically a plurality of safety mechanisms are provided.

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The transceiver may be spaced apart from the movement mechanism and connected by conventional means such as hydraulic line or electric cable. This allows the wireless signal to be transmitted over a smaller distance. For example the wireless signal can be transmitted from the wellhead apparatus to a transceiver up to 100m, sometimes less than 50m, or less than 20m below the top of the well which is connected though hydraulics or electric cabling to the obstructing member. This allows the safety mechanism in accordance with the present invention to operate even when the wellhead, wellhead apparatus or the top 100m, 50m or 20m of the well is damaged and control lines therein broken. Thus the benefits of embodiments can be focused on a particular areas. Accordingly embodiments of the present invention can be combined with fluid and/or electric control systems.

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~~Preferably a A~~ sensor is provided to detect a parameter in the well, preferably in the vicinity of the safety mechanism.

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Thus such sensors can provide important information on the environment in all parts of the well especially around the safety mechanism and the data from the sensors may provide information to an operator of an emergency situation that may be occurring or about to occur and may need intervention to mitigate the emergency situation.

The sensors need to operate only in an emergency situation but can also provide details on different parameters at any time. The sensors can be useful for cement tests, testing pressures on either side of packers, sleeves,
 5 valves or obstructions and wellhead pressure tests and generally for well information and monitoring from any location in the well.

The wireless signals may be sent retroactively, that is after an emergency situation has occurred, for example after a blow out.

10 Typically the sensors can store data for later retrieval and are capable of transmitting it.

The safety mechanism ~~is~~ ~~may be~~ adapted to move the obstructing member to/from the first position from/to the second position automatically in response
 15 to a parameter detected by the sensor. Thus at a certain "trip point" the safety mechanism can close the well, if for example, it detects a parameter indicative of unusual data or an emergency situation. Preferably the safety mechanism is adapted to function in such a manner in response to a plurality of different parameters all detecting unusual data, thus suggesting an
 20 emergency situation. The parameter may be any parameter detected by the sensor, such as pressure, temperature, flow, noise, or indeed the absence of flow or noise for example.

Such safety mechanisms are particularly useful during all phases when a
 25 BOP is in use and especially during non-drilling phases when a BOP is in use.

strain on pipes or any other parameters/sensors referred to herein but not limited to those.

Moreover with a plurality of sensors, the data may provide a profile of the
5 parameters (for example, pressure/temperature) along the casing and so aid
identification where the loss of integrity has occurred, e.g. whether the casing,
casing cement, float collar or seal assembly have failed to isolate the
reservoir or well. Such information can allow the operator to react in a quick,
safe and efficient manner; alternatively the safety mechanism can be adapted
10 to activate in response to certain detected parameters or combination of
parameters, especially where two or three parameters are showing unusual
values.

Such a system may be activated in response to an emergency situation.

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Also disclosed herein is ~~Thus the invention provides~~ a method of inhibiting
fluid flow from a well in an emergency situation, the method comprising:
in the event of an emergency, sending a wireless signal into the well to a
safety mechanism according to the first aspect of the invention.

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Preferred and other optional features of the previous embodiment are
preferred and optional features of the method according to the invention
immediately above.

25 An emergency or emergency situation is where uncontrolled fluid flow occurs
or is expected to occur, from a well; where an unintended explosion occurs or
there is an unacceptable risk that it may occur, where significant structural
damage of the well integrity is occurring or there is an unacceptable risk that it

Thus the device comprises a wireless transmitter, or transceiver and preferably also comprises a sonar receiver, to receive signals from a surface facility and especially a sonar transceiver so that it can communicate two-way
5 with the surface facility. For certain embodiments an electric line may be run into a well and the wireless transceiver attached towards one end of the line. In other embodiments the signal may be sent from an ROV via a hot-stab connection or via a sonar signal from the ROV.

- 10 Therefore also disclosed herein is ~~the invention also provides~~ a device, in use fitted or retro-fitted to a top of a well, comprising a wireless transmitter and a sonar receiver; especially for use in an emergency situation.

The device is relatively small, typically being less than 1 m^3 , preferably less
15 than 0.25 m^3 , especially less than 0.10 m^3 and so can be easily landed on the wellhead apparatus. The resulting physical contact between the wellhead apparatus and the device provides a connection to the well for transmission of the wireless signal. In alternative embodiments the device is built into the wellhead apparatus, which is often at the seabed but may be on land for a
20 land well.

Thus such devices also operate wirelessly and do not require physical communication between the wellhead apparatus and a controlling station, such as a vessel or rig.

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Embodiments of the invention also include a satellite device comprising a sonar transceiver and a satellite communication device. Such embodiments can communicate with the well, such as with said device at the wellhead

apparatus in accordance with a previous aspect of the invention, and relay signals onwards via satellite. The satellite device may be provided on a rig or vessel or a buoy.

- 5 ~~Thus also disclosed herein is~~ ~~Thus according to one aspect of the invention there is provided~~ a well apparatus comprising a well and a satellite device comprising a satellite communication mechanism, and a sonar, the device configured to relay information received from the sonar by satellite.

- 10 Preferably the device is independent of the rig, for example it may be provided on a buoy. Thus in the event that the rig is lost, the buoy may relay a control signal from a satellite to the well to shut down the well.

- 15 In a further embodiment the device at the wellhead apparatus may be wired to a surface or remote facility. Preferably however, the device is provided with further wireless communication options for communication with the surface facility. Typically the device has batteries to permit operation in the event of damage to the cable.

- 20 The safety mechanism may comprise a subsurface safety valve, optionally of known type, along with a wireless transceiver.

- 25 In alternative embodiments, the safety mechanism comprises a packer and an expansion mechanism. The movement mechanism causes the expansion mechanism to activate which expands the packer and so moving the packer from said first position to said second position.

said casing and a drill string/production tubing, are preferably reactive to an emergency situation that is unexpanded.

Thus also disclosed herein is ~~Thus the invention also provides a well~~

5 apparatus comprising: a plurality of casing strings;
a packer apparatus provided on one of the casing strings;
the packer apparatus comprising a wireless transceiver, and adapted to
expand in response to a change in a wireless signal in order to restrict flow of
fluid through an annulus between said casing string and an adjacent
10 elongate member.

As noted above, the packer may be provided in use in the expanded configuration and act as a permanent barrier to resists fluid flow or may be provided in the unexpanded configuration and activated as required, for
15 example in response to an emergency situation. Moreover the packer may be adapted to move from an expanded configuration, corresponding to the second position of the safety mechanism where fluid flow is restricted (normally blocked) and retract to the first position where fluid flow is permitted.

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The adjacent elongate member may be another of the casing strings or may be a drill pipe or may be production tubing.

The invention also provides a packer as described herein for use on a
25 production string in an emergency situation.

For example in a gas lift operation the packer may be provided on the production tubing and activated only in the event of an emergency.

Typically the packer is provided as a permanent barrier when the adjacent member is another casing string, and in the unexpanded configuration when the elongate member is a drill pipe ~~or~~ or production tubing that is they remain
 5 unexpanded until they expand in response to an emergency situation.

Whilst the packer of the packer apparatus may expand in an inward or outward direction, preferably it is adapted to expand in an inward direction.

10 The annulus may be a casing annulus.

Thus an advantage of such embodiments is that fluid flow through an annulus can be inhibited, preferably stopped, by provision of such a packer in an annulus. Normally fluid does not flow through the casing annulus of a well
 15 and so the skilled person would not consider placing a packer in this position. However the inventors of the present invention have realised that the casing annulus is a flow path through which well fluid may flow in the event of a well failure and blow out. Such an event may be due to failure of the formation, cement and/or seals provided with the casing system and wellhead.

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Preferably a plurality of packer apparatus are provided. Different packer apparatus may be provided in the same or in different annuli.

Preferably the packer apparatus is/are provided proximate to the top of the well. In this way the packers can typically inhibit fluid flow above the fault or
 25 suspected fault, in the casing. Therefore the packer(s) may be provided within 100m of the wellhead, more preferably within 50m, especially within 20m, and ideally within 10m.

The packers provided in a casing annulus may be non-weight packers, that is they do not necessarily have engaging teeth for example the packers may be inflatable or swell types.

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The casing packers may be installed above the cemented-in section of the casing and they thus typically provide an additional barrier to flow of fluids above that traditionally provided by a portion of the well being cased in.

10 In alternative embodiments the packers may be provided on an inner side of the casing adjacent to a cemented in portion of the casing, thus inhibiting a flow path at this point, whilst the cement inhibits the flow path on the outside portion of the casing.

15 The safety mechanism may be a packer-like element without a through bore and so in effect function as a well plug or bridge plug.

In certain embodiments, the packer may be provided on a drill string.

20 Thus also disclosed herein is ~~Thus the invention provides a method of drilling,~~ comprising during a drilling phase providing a drill string comprising a packer apparatus as defined herein.

25 As drill strings typically rotate and move vertically in a well during a drilling phase, a skilled person would not be minded to provide a packer thereon since a packer resists movement. However the inventors of the present invention note that a packer provided thereof can be used in an emergency situation and so provides advantages.

Thus the packer may be provided on drill string, production string, production sub-assembly and may operate in cased or uncased sections of the well.

- 5 The safety mechanisms and packers described herein may also have additional means of operation such as hydraulic and/or electric lines.

Thus also disclosed herein is the present invention also provides a method of
deploying a safety mechanism according to the present invention, monitoring
10 the well using data received from sensors as described herein associated with the safety mechanism whilst abandoning the well and/or cementing the well and/or suspending the well.

Unless otherwise stated methods and mechanisms of various aspects of the
15 present invention may be used in all phases including drilling, suspension, production/injection, completion and/or abandonment of well operations.

The wireless signal for all embodiments is preferably an acoustic signal although may be an electromagnetic or any other signal or combination of
20 signals.

Preferably the acoustic communications include Frequency Shift Keying ((FSK) and/or Phase Shift Keying (PSK) modulation methods, and/or more advanced derivatives of these methods, such as Quadrature Phase Shift
25 Keying (QPSK) or Quadrature Amplitude Modulation (QAM), and preferably incorporating Spread Spectrum Techniques. Typically they are adapted to automatically tune acoustic signalling frequencies and methods to suit well conditions.

Claims

1. A safety mechanism comprising:
5 an obstructing member moveable between a first position where fluid flow is permitted, and a second position where fluid flow is restricted;
a movement mechanism;
and a wireless receiver, adapted to receive a wireless signal;
wherein the movement mechanism is operable to move the obstructing
10 member from one of the first and second positions to the other of the first and second positions in response to a change in the signal being received by the wireless receiver.
2. A safety mechanism as claimed in claim 1, comprising a wireless
15 transceiver.
3. A safety mechanism as claimed in either preceding claim, wherein the second position is a closed position where fluid flow is stopped.
- 20 4. A safety mechanism as claimed in any preceding claim, wherein the receiver is an acoustic receiver and the signal is an acoustic signal.
5. A safety mechanism as claimed in any one of claims 1 to 3, wherein the receiver is an electromagnetic receiver and the signal is an
25 electromagnetic signal.
6. A safety mechanism as claimed in claim 5, wherein an acoustic receiver is also provided and the signal is transmitted over part of its distance

by the electromagnetic receiver and part of its distance by the acoustic receiver.

7. A safety mechanism as claimed in any preceding claim, wherein the receiver is spaced apart from the movement mechanism and connected by a hydraulic line or an electric cable.

8. A safety mechanism as claimed in any preceding claim, adapted to move the obstructing member to/from the first position from/to the second position automatically in response to a level of a parameter detected by a sensor.

9. A safety mechanism as claimed in claim 8, wherein the level of the parameter at which the safety mechanism is adapted to move the obstructing member to/from the first position from/to the second position is variable by an operator.

10. A safety mechanism as claimed in any preceding claim, adapted to move the obstructing member to/from the first position from/to the second position automatically in the absence of a signal over a pre-determined period of time.

11. A safety mechanism as claimed in any preceding claim, wherein the safety mechanism is adapted to activate the transceiver to send signals after an emergency situation has occurred.

12. A safety mechanism as claimed in any preceding claim, comprising a packer and an expansion mechanism and the movement mechanism causes

the expansion mechanism to activate which expands the packer and so move the packer between said first position and said second position.

13. A safety mechanism as claimed in any one of claims 1 to 11,
5 comprising a plug with an expansion mechanism and the movement mechanism causes the expansion mechanism to activate which expands the plug and so move the plug between said first position and said second position.

10 14. A safety mechanism as claimed in any one of claims 1 to 11, comprising a valve.

15 15. A safety mechanism as claimed in claim 14, wherein the valve comprises a sleeve moveable between the first and the second position.

16. A safety mechanism as claimed in claim 14 or claim 15, wherein the valve is provided in a casing sub and is adapted to move from one of the first and second positions to the other of the first and second positions, and then back to the first of the first and second positions.

20 17. A well comprising at least one safety mechanism as claimed in any preceding claim.

25 18. A well as claimed in claim 17, further comprising a subsurface safety valve.

19. A well as claimed in claim 17 or claim 18, wherein a sensor is provided to detect a parameter in the well, in the vicinity of the safety mechanism.

20. A well as claimed in claim 19, wherein a sensor is provided above and a sensor is provided below the safety mechanism.

5 21. A well as claimed in claim 20, wherein the sensors detect pressure above and below the safety mechanism.

22. A well as claimed in any one of claims 17 to 21, wherein the receiver is up to 100m, optionally less than 50m, more optionally less than 20m below
10 the top of the well.

23. A well as claimed in any one of claims 17 to 22, comprising a casing having a casing sub with the safety mechanism in the form of a valve therein, the valve communicating between an inner and outer side of the casing;
15 wherein the valve is adapted to move from one of the first and second positions to the other of the first and second positions, and then back to the first of the first and second positions.

24. A well apparatus comprising a well as claimed in any one of claims 17
20 to 23, and a sonar receiver and preferably a sonar transmitter.

25. A well apparatus as claimed in claim 24, wherein a satellite device is provided, the device comprising a satellite communication mechanism and configured to relay information received between the sonar receiver and
25 transmitter and the satellite.

26. A method of inhibiting fluid flow from a well as claimed in any one of
claims 17 to 23 or a well apparatus as claimed in claim 24 or 25 in an

emergency situation, the method comprising: in the event of an emergency situation, sending a wireless signal into the well to the safety mechanism.

27. A method as claimed in claim 26, wherein the wireless signal is sent
5 during a phase where a BOP is provided on the well.

28. A method as claimed in claim 26 or claim 27, wherein the wireless
signal is sent from a device provided at a wellhead apparatus of the well or
proximate thereto.
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29. A method as claimed in claim 27, wherein the wireless signal is sent
from a platform, optionally with wireless repeaters provided on risers and/or
downhole.

30. A method as claimed in any one of claims 26 to 27, wherein the
wireless signal is sent from the seabed wellhead apparatus, after receiving
sonar signals from a surface installation or an ROV.
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31. A method as claimed in any one of claims 26 to 27 wherein an ROV
20 connects to the seabed wellhead apparatus and send or receives signals via
a hot-stab connection.

32. A method as claimed in claim 26 to 28, wherein the wireless signal is
sent from the wellhead apparatus after receiving satellite signals from another
25 location.

33. A packer apparatus comprising a packer and an activation mechanism,
the activation mechanism comprising an expansion mechanism for expanding

the packer and a wireless receiver preferably transceiver adapted to receive a wireless control signal and control the activation mechanism.

34. A packer apparatus as claimed in claim 33, wherein the receiver is an acoustic transceiver and the signal is an acoustic signal.

35. A method of drilling, comprising during a drilling phase providing a drill string comprising a packer apparatus as claimed in claim 33 or claim 34.

36. A well apparatus comprising:
a plurality of casing strings;
a packer apparatus as claimed in claim 33 or claim 34 on at least one of the casing strings in order to restrict flow of fluid through an annulus between at least one of said casing strings and an adjacent elongate member.

37. A well apparatus as claimed in claim 36, wherein sensors and/or receivers are provided in at least one casing annulus defined between two of the casing strings.

38. A well apparatus as claimed in claim 36 or 37, wherein the packer is provided on the casing string adjacent a cemented-in portion of the casing.

39. A well apparatus as claimed in claim 36 to claim 38, wherein the packer is provided in use in the expanded configuration and acts as a permanent barrier to resist fluid flow.

40. A well apparatus as claimed in claim 36 to claim 38, wherein the packer is provided in use in the unexpanded configuration and adapted to activate in response to an emergency situation.

5 41. A well apparatus as claimed in any one of claims 36 to 40, wherein the packer is adapted to expand in an inward direction.

42. A well apparatus as claimed in any one of claims 36 to 41, wherein the packer is provided within 100m of the wellhead, optionally more within 50m,
10 especially within 20m, and more especially within 10m.

43. A method of deploying a safety mechanism according claims 1 to 16, comprising monitoring the well using data received from sensors whilst abandoning the well and/or cementing the well and/or suspending the well.

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44. A well with a device which is in use fitted or retro-fitted to a top of the well, comprising a wireless transmitter and a sonar receiver; for use in an emergency situation.

20 45. A well as claimed in claim 44, wherein the device is less than 1m^3 , less than 0.25m^3 , especially less than 0.10m^3 .

Claims

1. A safety mechanism comprising:
 - 5 an obstructing member moveable between a first position where fluid flow is permitted, and a second position where fluid flow is restricted;
 - a movement mechanism;
 - and a wireless receiver, adapted to receive a wireless signal;
 - wherein the movement mechanism is operable to move the obstructing
 - 10 member from one of the first and second positions to the other of the first and second positions in response to a change in the signal being received by the wireless receiver;
 - wherein the movement mechanism is adapted to move the obstructing member from one of the first and second positions to the other of the first and
 - 15 second positions automatically in response to at least one level of a parameter detected by a sensor; and wherein the level of the parameter at which the safety mechanism is adapted to move the obstructing member to/from the first position from/to the second position is variable by an operator.
- 20 2. A safety mechanism as claimed in claim 1, comprising a wireless transceiver.
3. A safety mechanism as claimed in either preceding claim, wherein the
- 25 second position is a closed position where fluid flow is stopped.
4. A safety mechanism as claimed in any preceding claim, wherein the receiver is an acoustic receiver and the signal is an acoustic signal.

5. A safety mechanism as claimed in anyone of claims 1 to 3, wherein the receiver is an electromagnetic receiver and the signal is an electromagnetic signal.
- 5 6. A safety mechanism as claimed in claim 5, wherein an acoustic receiver is also provided and the signal is transmitted over part of its distance by the electromagnetic receiver and part of its distance by the acoustic receiver.
- 10 7. A safety mechanism as claimed in any preceding claim, wherein the receiver is spaced apart from the movement mechanism and connected by a hydraulic line or an electric cable.
8. A safety mechanism as claimed in any preceding claim, adapted to
15 move the obstructing member to/from the first position from/to the second position automatically in the absence of a signal over a pre-determined period of time.
9. A safety mechanism as claimed in any preceding claim, wherein the
20 safety mechanism is adapted to activate the transceiver to send signals after an emergency situation has occurred.
10. A safety mechanism as claimed in any preceding claim, comprising a
25 packer and an expansion mechanism and the movement mechanism causes the expansion mechanism to activate which expands the packer and so move the packer between said first position and said second position.

11. A safety mechanism as claimed in claim 10, which is provided on the casing.

12. A safety mechanism as claimed in anyone of claims 1 to 9, comprising
5 a plug with an expansion mechanism and the movement mechanism causes the expansion mechanism to activate which expands the plug and so move the plug between said first position and said second position.

13. A safety mechanism as claimed in anyone of claims 1 to 9, comprising
10 a valve.

14. A safety mechanism as claimed in claim 13, wherein the valve comprises a sleeve moveable between the first and the second position.

15 15. A safety mechanism as claimed in claim 13 or claim 14, wherein the valve is provided in a casing sub and is adapted to move from one of the first and second positions to the other of the first and second positions, and then back to the first of the first and second positions.

20 16. A safety mechanism as claimed in any preceding claim, wherein the obstructing member is adapted to move to/from the first position from/to the second position automatically in response to a level of a plurality of different parameters.

25 17. A safety mechanism as claimed in any preceding claim, wherein the at least one parameter detected by the sensor is at least one of pressure, temperature, flow and noise.

18. A safety mechanism as claimed in any preceding claim, wherein said automatic response to the level of the at least one parameter, is the absence of the at least one parameter.

5 19. A safety mechanism as claimed in any preceding claim, wherein, in use, the level of the parameter at which the safety mechanism is adapted to move the obstructing member to/from the first position from/to the second position is varied by sending instructions to a receiver coupled to or integral with sensors or the safety mechanism.

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20. A method of deploying a safety mechanism according any preceding claim, comprising monitoring the well using data received from sensors whilst abandoning the well and/or cementing the well and/or suspending the well.