WHAT IS CLAIMED IS:

1. An apparatus useable in an offshore drilling installation having a mud loop into a well drilled below the seabed, the apparatus comprising:

a first sensor configured to measure a input mud flow pumped into the well;

a second sensor configured to measure a variation of a return mud flow emerging from the well; and

a controller connected to the first sensor, and to the second sensor and configured to identify an ongoing or imminent kick event based on monitoring and comparing an evolution of the input mud flow as measured by the first sensor and an evolution of the return mud flow as inferred based on measurements received from the second sensor.

2. The apparatus of claim 1, wherein the controller is configured to generate an alarm signal upon identifying the ongoing or imminent kick event.

3. The apparatus of claim 1, wherein the first sensor comprises a stroke counter connected to a fluid pump that pumps the input mud flow, or other flow measuring device mounted in the inlet or discharge piping to the fluid pump.

4. The apparatus of claim 1, wherein the second sensor is configured to detect the variation of the return mud flow near the seabed.

5. The apparatus of claim 1, wherein the controller is configured to take into consideration a delay between a normal increase or decrease of the input mud flow pumped into the well and the variation of the return mud flow caused by the normal increase or decrease of the input mud flow pumped into the well.

6. The apparatus of claim 5, wherein the controller identifies the ongoing or imminent kick event when the return mud flow increases while the input mud flow pumped into the well is substantially constant.

7. The apparatus of claim 5, wherein the controller identifies the ongoing or imminent kick event when the return mud flow remains substantially constant or increases while the input mud flow pumped into the well decreases.

8. The apparatus of claim 1, wherein the controller and/or the first sensor and/or the second sensor transmit measurements related to monitoring the input mud flow and the return mud flow to an operator interface located at the surface.

9. The apparatus of claim 1, wherein the controller is configured to filter out fluctuations in time and/or in magnitude of the return mud flow, if the fluctuations are below predetermined respective thresholds.

10. The apparatus of claim 1, wherein the controller is configured to extract trends in the evolution of the input mud flow pumped into the well and in the evolution of the return mud flow.

11. The apparatus of claim 1, further comprising a third sensor connected to the controller to provide measurements related to ongoing drilling,

wherein the controller uses the measurements of the third sensor to confirm that the ongoing or imminent kick event has occurred.

12. A method of manufacturing an offshore drilling installation, the method comprising:

providing a first sensor configured to measure a input mud flow pumped into the well, and a second sensor configured to measure a variation of a return mud flow emerging from the well, and

connecting a controller to the first sensor and to the second sensor, the controller being configured to identify an ongoing or imminent kick event based on monitoring comparatively an evolution of the input mud flow as measured by the first sensor and an evolution of the return mud flow as inferred based on measurements received from the second sensor.

13. The method of claim 12, further comprising connecting the controller to blowout preventers of the installation to trigger closing thereof upon receiving an alarm signal generated by the controller to indicate identifying the ongoing or imminent kick event.

14. The method of claim 12, wherein the first sensor comprises a stroke counter connected to a fluid pump providing the input mud flow, or other flow measuring device mounted in the inlet or discharge piping to the fluid pump.

15. The method of claim 12, wherein the second sensor is configured to detect the variation of the return mud flow near the seabed.

16. The method of claim 12, wherein the controller is configured to take into consideration a delay between a normal increase or decrease of the input mud flow pumped into the well and the variation of the return mud flow caused by the normal increase or decrease of the input mud flow pumped into the well and to identify the identifies the

ongoing or imminent kick event when the return mud flow increases while the input mud flow pumped into the well is substantially constant or when the return mud flow remains substantially constant or increases while the input mud flow pumped into the well decreases.

17. The method of claim 12, further comprising connecting the controller to an operator interface located at the surface, to transmit measurements received from the first sensor and from the second sensor.

18. The method of claim 12, wherein the controller is configured to perform at least one of

filtering out fluctuations in time and/or in magnitude of the return mud flow, if the fluctuations are below predetermined respective thresholds, and

extracting trends in the evolution of the input mud flow pumped into the well and in the evolution of the return mud flow.

19. The method of claim 12, further comprising

connecting a third sensor configured to provide measurements related to the drilling, to the controller,

wherein the controller is further configured to confirm that the ongoing or imminent kick event has occurred based on the measurements received from the third sensor.

20. A method of identifying an ongoing or imminent kick event in an offshore drilling installation having a mud loop into a well drilled below the seabed, the method comprising:

receiving measurements from a first sensor configured to measure an input mud flow pumped into the well and a second sensor configured to measure a variation of a return mud flow emerging from the well; and

based on the received measurements, monitoring and comparing an evolution of the input mud flow and an inferred evolution of for the return mud flow, to identify the ongoing or imminent kick event (1) when the return mud flow increases while the input mud flow pumped into the well is substantially constant, or (2) when the return mud flow remains substantially constant or increases while the input mud flow pumped into the well decreases, while taking into consideration a delay between a normal increase or decrease of the input mud flow pumped into the well and the variation of the return mud flow caused by the normal increase or decrease of the input mud flow pumped into the well.

21. The method of claim 20, further comprising at least one of:

generating an alarm signal upon identifying the ongoing or imminent kick event; and

transmitting the measurements received from the first sensor and from the second sensor to an operator interface located at the surface.

22. The method of claim 20, further comprising at least one of:

filtering out fluctuations in time and/or in magnitude of the return mud flow, if the fluctuations are below predetermined respective thresholds; and

extracting trends in the evolution of the input mud flow pumped into the well and in the evolution of the return mud flow.

23. The method of claim 20, further comprising confirming that the ongoing or imminent kick event has occurred based on measurements received from a third sensor.

CLAIMS

1. An apparatus useable in an offshore drilling installation having a mud loop into a well drilled below a seabed, the apparatus comprising:

a blowout preventer coupled to a wellhead disposed on the seabed, the blowout preventer located near the seabed;

a riser coupled to the blowout preventer, the riser including a casing circumscribing a drill string to define an annular space therebetween;

a first sensor connected to a fluid pump, the fluid pump disposed at a surface location and configured to pump an input mud flow into the well to thereby circulate a drilling mud, the first sensor configured to measure the input mud flow pumped into the well;

a second sensor disposed near the seabed and configured to provide measurements indicating a variation of a return mud flow emerging from the well, the return mud flow flowing from the well towards the surface location via the annular space defined between the casing of the riser and the drill string; and

a controller in communication with to the first sensor and to the second sensor and configured to perform the following to identify a likely occurrence of an ongoing or imminent kick event, to include:

monitoring and comparing an evolution of the input mud flow based on measurements received from the first sensor, and an evolution of the return mud flow based on measurements received from the second sensor, and

identifying the likely occurrence of an ongoing or imminent kick event when:

the variation of the return mud flow increases while the input mud flow pumped into the well is substantially constant, or

the variation of the return mud flow remains substantially constant or increases while the input mud flow pumped into the well decreases.

2. The apparatus of claim 1,

wherein the identifying the likely occurrence of an ongoing or imminent kick event includes taking into consideration a delay between:

a normal increase or decrease of the input mud flow pumped into the well as measured by the first sensor, and

an expected variation of the return mud flow, caused by the normal increase or decrease in the input mud flow pumped into the well; and

wherein the controller is further configured to:

determine the expected variation of the return mud flow,

determine the delay between the normal increase or decrease of the input mud flow pumped into the well as measured by the first sensor, and the expected variation of the return mud flow as measured by the second sensor, caused by the normal increase or decrease in the input mud flow pumped into the well, and

generate an alarm signal upon identifying the likely occurrence of an ongoing or imminent kick event.

3. The apparatus of claim 1,

wherein the blowout preventer comprises one or more blowout preventer units configured to be in an open state during normal drilling operations and to be switched to a closed state to interrupt the return mud flow through the riser; and

wherein the controller is further configured:

to control the one or more blowout preventer units to be in the open state during the normal drilling operations, and

to switch one or more of the one or more blowout preventer units into the closed state in response to identifying the likely occurrence of an ongoing or imminent kick event to thereby interrupt a fluid flowing therethrough, the fluid comprising the return mud flow.

4. The apparatus of claim 3, wherein the controller comprises one or both blowout preventer control pods.

5. The apparatus of claim 4 further comprising,

one or more electrical or both electrical and hydraulic lines extending between the blowout preventer and a surface platform, defining an umbilical, the umbilical configured to provide for transporting signals between the one or both blowout preventer control pods and an operator interface on the surface platform; and

wherein the one or both blowout preventer control pods is or are further configured to:

receive measurements from the first and the second sensors, and

transmit one or both of the following to the operator interface:

the measurements received from the first and the second sensors, and

measurements related to monitoring the input mud flow and the return mud flow to provide for visualization of the evolution of the input mud flow, the return mud flow, or both the input mud flow and the return mud flow.

6. The apparatus of claim 4, wherein the one or both blowout preventer control pods is further configured:

to generate an alarm signal indicating the likely occurrence of an ongoing or imminent kick event;

to transmit the alarm signal to the operator interface, the alarm signal indicating the likely occurrence of an ongoing or imminent kick event;

to trigger closing of the one or more blowout preventer units; and

to transmit information related to the current state of the one or more blowout preventer units to the operator interface.

7. The apparatus of claim 6, wherein the one or more blowout preventer control pods is or are further configured to identify the likely occurrence of an ongoing or imminent kick event when either:

the variation of the return mud flow increases while the input mud flow pumped into the well is substantially constant; or

the variation of the return mud flow remains substantially constant or increases while the input mud flow pumped into the well decreases.

8. The apparatus of claim 7, wherein the variation of the return mud flow is a derivative of a measurement of the return mud flow.

9. The apparatus of claim 6, wherein the second sensor comprises a flow measuring device located at a detection site sufficiently near the wellhead to provide for early detection of the likely occurrence of an ongoing or imminent kick event, the detection site for the second sensor located both:

adjacent to the wellhead to measure characteristics of the return mud flow when emerging from the wellhead to thereby provide the measurements indicating a variation of the return mud flow emerging from the well, and

adjacent to the one or more blowout preventer control pods to connect thereto.

10. The apparatus of claim 1, wherein the second sensor comprises a flow measuring device positioned to receive the return mud flow emerging from the wellhead, and to provide flow-related measurements thereof.

11. The apparatus of claim 1, wherein the second sensor comprises one or more of the following:

a pressure sensor;

an electromagnetic sensor monitoring impedance of the return mud flow;

an acoustic sensor monitoring acoustic impedance of the return mud flow; and

an ultrasonic sensor measuring the velocity of the return mud flow.

12. The apparatus of claim 1, wherein the second sensor comprises a combination of sensors combined to provide a reliable basis for estimating the return mud flow, neither sensor of the combination of sensors forming the second sensor individually providing a reliable basis for estimating the return mud flow.

13. The apparatus of claim 6, wherein the one or more blowout preventer control pods is or are further configured to:

determining trends in the evolution of the input mud flow pumped into the well, and

determining trends in the evolution of the return mud flow to identify whether the rate of the return mud flow is changing greater than the respective predetermined threshold.

14. The apparatus of claim 6, further comprising:

a third sensor connected to the one or more blowout preventer control pods and configured to provide measurements related to ongoing drilling; and

wherein the one or more blowout preventer control pods is or are further configured to confirm existence of the likely occurrence of an ongoing kick event based on the measurements of the third sensor before generating the alarm signal.

15. The apparatus of claim 14, wherein the third sensor is configured to provide for detecting a density change in the return mud flow.

16. The apparatus of claim 14, wherein the measurements provided by the third sensor are not flow measurements, the third sensor utilizing a different measurement principle than that of the second sensor.

17. A method of manufacturing an offshore drilling installation, the method comprising:

coupling a riser, a lower marine riser package and a blowout preventer to a wellhead of a well, the well drilled below a seabed beneath a water surface, the blowout preventer comprising one or more blowout preventer units forming a stack, each blowout preventer unit being configured to be in an open state during normal drilling operations and to be switched to a closed state to interrupt a fluid flowing therethrough;

providing a drill string extending through a casing of the riser such that an annular space between the casing of the riser and the drill string;

providing a first sensor configured to measure an input mud flow pumped into the well, and a second sensor configured to measure a variation of a return mud flow emerging from the well and entering the annular space between the casing of the riser and the drill string to complete a mud loop,

the first sensor connected to a fluid pump disposed at a surface location, the fluid pump configured to pump the input mud flow into the well to thereby circulate a drilling mud, and

the second sensor comprising a flow measuring device disposed near the seabed at a detection site sufficiently near the wellhead to provide for early detection of a likely occurrence of an ongoing or imminent kick event, the detection site for the second sensor being located both:

adjacent to the wellhead to measure characteristics of the return mud flow emerging from the wellhead and entering the annular space between the casing of the riser and the drill string en route to the surface location, and

adjacent to a controller to connect thereto, the controller comprising one or more blowout preventer control pods located near the seabed and connected to a portion or portions of the blowout preventer; and

connecting the first sensor and the second sensor to the one or more blowout preventer control pods, each of the one or more blowout preventer control pods being configured to perform the following steps to identify the likely occurrence of an ongoing or imminent kick event, to include:

receiving measurements from the first sensor,

receiving measurements from the second sensor,

monitoring comparatively an evolution of the input mud flow based on the measurements received from the first sensor, and an evolution of the return mud flow as inferred based on measurements received from the second sensor defining an inferred evolution of the return mud flow, and

identifying the likely occurrence of an ongoing or imminent kick event responsive to the monitoring and comparing, the likely occurrence of an ongoing or imminent kick event identified when either:

a variation of the inferred evolution of the return mud flow increases while the evolution of the input mud flow pumped into the well is substantially constant, or

the variation of the inferred evolution of the return mud flow remains substantially constant or increases while the evolution of the input mud flow pumped into the well decreases, while taking into consideration a delay between:

a normal increase or decrease of the evolution of the input mud flow pumped into the well as measured by the first sensor, and

an expected variation of the evolution of the return mud flow, caused by the normal increase or decrease in the evolution of the input mud flow pumped into the well.

18. The method of claim 14, further comprising:

connecting the one or more blowout preventer control pods to the blowout preventer of the installation; and

performing the following by the one or more blowout preventer control pods:

controlling the one or more blowout preventer units to be in an open state during the normal drilling operations,

generating an alarm signal indicating the likely occurrence of an ongoing or imminent kick event,

transmitting the alarm signal to an operator interface located on a surface platform at the surface, the alarm signal indicating the likely occurrence of an ongoing or imminent kick event,

triggering closing of the one or more blowout preventer units, and

transmitting information related to the current state of the one or more blowout preventer units to the operator interface.

19. The method of claim 17, wherein the controller is further configured to:

determine the delay between the normal increase or decrease of the evolution of the input mud flow pumped into the well as measured by the first sensor, and the expected variation of the return mud flow as measured by the second sensor, caused by the normal increase or decrease in the evolution of the input mud flow pumped into the well; and

determine the expected variation of the return mud flow.

20. The method of claim 17, wherein the variation of the return mud flow is a derivative of a measurement of the return mud flow.

21. The method of claim 17, further comprising:

connecting one or more electrical or both electrical and hydraulic lines between the blowout preventer and a surface platform, defining an umbilical;

operably coupling the umbilical to both the one or more blowout preventer control pods and to an operator interface located on the surface platform; and

transmitting one or more of the following to the operator interface via the umbilical:

measurements received from the first sensor and from the second sensor by the one or more blowout preventer control pods, and

measurements related to monitoring the input mud flow and the return mud flow to provide for visualization of the evolution of the input mud flow, the return mud flow, or both the input mud flow and the return mud flow.

22. The method of claim 17, wherein the one or more blowout preventer control pods is or are configured to perform at least one of

filtering out fluctuations in time and in magnitude of the return mud flow, if the fluctuations are below predetermined respective thresholds;

determining trends in the evolution of the input mud flow pumped into the well; and

determining trends in the evolution of the return mud flow to identify whether the rate of the return mud flow is changing greater than the respective predetermined threshold.

23. The method of claim 17, further comprising:

connecting a third sensor to the one or more blowout preventer control pods, the third sensor configured to provide measurements related to the drilling,

wherein the one or more blowout preventer control pods is or are further configured to confirm the likely occurrence of an ongoing or imminent kick event based on the measurements received from the third sensor, before generating an alarm signal.

24. A method of identifying an ongoing or imminent kick event in an offshore drilling installation having a wellhead disposed on a seabed disposed beneath a water surface, and a mud loop into a well drilled below the seabed, the method comprising:

connecting a blowout preventer and riser assembly to the wellhead, wherein the blowout preventer and riser assembly includes a riser casing circumscribing a drill string to

define an annular space therebetween, the blowout preventer comprising one or more blowout preventer units forming a stack, each blowout preventer unit being configured to be in an open state during normal drilling operations and to be switched to a closed state to interrupt a fluid flowing therethrough;

connecting one or more electrical or both electrical and hydraulic lines between the blowout preventer and a surface platform, defining an umbilical;

operably coupling the umbilical to both an operator interface disposed on the surface platform and one or more blowout preventer control pods connected to a portion or portions of the blowout preventer to provide for communicating therebetween;

receiving measurements from a first sensor configured to provide measurements indicating an input mud flow pumped into the well the first sensor connected to a fluid pump disposed at a surface location on the surface platform, the fluid pump configured to pump the input mud flow into the well to thereby circulate a drilling mud;

receiving measurements from a second sensor configured to provide measurements indicating a variation of a return mud flow emerging from the well near the seabed and entering the annular space defined between the riser casing and the drill string, wherein the variation of the return mud flow is a derivative of a measurement of the return mud flow, the second sensor comprising a flow measuring device disposed near the seabed at a detection site sufficiently near the wellhead to provide for early detection of a likely occurrence of an ongoing or imminent kick event, the detection site for the second sensor being located both:

adjacent to the wellhead to measure characteristics of the return mud flow emerging from the wellhead and entering the annular space between the casing of the riser and the drill string en route to the surface location, and

adjacent to a controller to connect thereto at a distance sufficient to prevent substantial travel time delays, the controller comprising one or more blowout preventer control pods located near the seabed and connected to a portion of the blowout preventer;

based on the received measurements, monitoring and comparing an evolution of the input mud flow and an inferred evolution of for the return mud flow; and

identifying existence of the likely occurrence of an ongoing or imminent kick event responsive to the monitoring and comparing:
when the derivative of the measurement of the return mud flow increases while the input mud flow pumped into the well is substantially constant, or

when the derivative of the measurement of the return mud flow remains substantially constant or increases while the input mud flow pumped into the well decreases, while taking into consideration a delay between:

a normal increase or decrease of the input mud flow pumped into the well, and

the variation of the return mud flow caused by the normal increase or decrease of the input mud flow pumped into the well.

25. The method of claim 24, further comprising the following performed by the one or more blowout preventer control pods:

generating an alarm signal upon identifying the likely occurrence of an ongoing or imminent kick event;

triggering closing of the one or more blowout preventer units;

transmitting the measurements received from the first sensor and from the second sensor to an operator interface located at the surface; and

transmitting information related to the current state of the one or more blowout preventer units to the operator interface.

26. The method of claim 24, further comprising at least one of:

configuring the second sensor to provide measurements indicating a change in the rate of the return mud flow emerging from the well near the seabed;

filtering out fluctuations in time and in magnitude of the return mud flow, if the fluctuations are below predetermined respective thresholds;

determining trends in the evolution of the input mud flow pumped into the well; and

determining trends in the evolution of the return mud flow.

27. The method of claim 24, further comprising confirming existence of the likely occurrence of an occurrence of ongoing or imminent kick event based on measurements received from a third sensor.