

1 APPARATUS, SYSTEMS AND METHODS FOR OIL AND GAS OPERATIONS

2

3 The present invention relates to apparatus, systems and methods for oil and gas
4 operations. In particular, the present invention relates to apparatus, systems and methods
5 for administering or delivering fluids to subsea hydrocarbon production flow systems. The
6 invention has particular, but not exclusive application to scale squeeze operations for
7 hydrocarbon wells, and gas lift operations for production pipelines, flow lines and risers.

8

9 Background to the invention

10

11 In the field of subsea engineering for the hydrocarbon production industry, it is known to
12 introduce fluids to subsea flow systems and/or hydrocarbon wells. In some such
13 applications, chemicals are injected in the flow systems and/or hydrocarbon wells to treat
14 the flow system, the well, or the reservoir itself. For example, a scale squeeze operation,
15 is carried out to remove unwanted build-up of scale and deposits inside the production

1 tubing of a subsea well by the injection of chemicals from a pumping skid on a vessel or a
2 subsea module.

3
4 Other fluid injection operations are used to optimise hydrocarbon production. For example,
5 gas-lift methods involve injecting gas into the flow of production fluid in a pipeline and/or at
6 the base of the riser in order to reduce its density, thus making it easier to recover to
7 surface.

8
9 Typically, appropriate dosing of the treatment chemical is calculated to provide effective
10 treatment without a significant excess of the treatment chemical, which may be harmful to
11 the downstream subsea production flow system, particularly where the flow system
12 comprises components susceptible to damage or corrosion. Examples include production
13 flow systems that comprise carbon steel, titanium (including flexible riser joints) or
14 elastomeric components or other systems which are not fully comprised of corrosion
15 resistant alloys. However, it can be difficult to fully eliminate or reduce to an acceptable
16 level the excess in treatment chemical, which may result in unspent chemicals passing
17 through the production system when production commences. This flow back of treatment
18 chemicals can be detrimental to the integrity of the system.

19
20 Summary of the invention

21
22 There is generally a need for a method and apparatus which addresses one or more of the
23 problems identified above.

24
25 It is amongst the aims and objects of the invention to provide a method and/or apparatus
26 that obviates or mitigates one or more drawbacks or disadvantages of available subsea
27 fluid injection systems and methodology, including chemical treatment systems for subsea
28 wells and/or production flow systems and gas lift systems and method.

29
30 Other aims and objects will become apparent from the following description.

31
32 According to a first aspect of the invention, there is provided an apparatus for introducing a
33 fluid into a subsea production flow system, the apparatus comprising:
34 a first flow path through the apparatus for fluidly coupling a subsea well to a subsea
35 production flow system;

1 an inlet for receiving the introduced fluid;
2 a second flow path fluidly connecting the inlet and the subsea production flow system;
3 a valve operable to control the flow of the introduced fluid through the inlet to the subsea
4 production flow system; and
5 at least one flow barrier in the first flow path, preventing the passage of the introduced fluid
6 from the inlet to the subsea well.

7

8 The apparatus may be configured to be connected to the flow system anywhere in the
9 jumper flowline envelope of the flow system.

10

11 The apparatus may be configured to be connected to an external flowline connector of the
12 flow system or a manifold thereof, at a location selected from the group consisting of: a
13 jumper flow line connector; upstream of a jumper flow line or a section of a jumper flow
14 line; downstream of a jumper flow line or a section of a jumper flow line; a Christmas tree;
15 a subsea collection manifold system; subsea Pipe Line End Manifold (PLEM); a subsea
16 Pipe Line End Termination (PLET); a subsea Flow Line End Termination (FLET); and a
17 subsea in-line tee (ILT). Alternatively, or in addition, the apparatus may be configured to
18 be connected (directly or otherwise) to a production riser, such that it is in fluid
19 communication with the production riser.

20

21 The apparatus may be configured to be connected to an external flowline connector of
22 any: jumper flow line; section of a jumper flow line; Christmas tree; subsea collection
23 manifold system; subsea Pipe Line End Manifold (PLEM); subsea Pipe Line End
24 Termination (PLET); subsea Flow Line End Termination (FLET); subsea in-line tee (ILT);
25 and production riser.

26

27 The apparatus may be connected to the flow system directly. Alternatively, the apparatus
28 may be located (partially or wholly) on a flow access apparatus (or multiple flow access
29 apparatus) which is located on the flow system.

30

31 The second flow path may connect the inlet to the subsea production flow system via at
32 least a part of the first flow path. The first and second flow paths may be in fluid
33 communication.

34

35 The at least one flow barrier may be a check valve.

1

2 The at least one flow barrier may be a flow restrictor, such as a choke valve. A controllable
3 choke valve may be provided which is operable to create a flow restriction and which may
4 create pressure drop in the system. This may result in a favourable flow route for the
5 introduced fluid upon entry into the apparatus via the valve and the inlet. The pressure
6 drop generated may cause the introduced fluid to preferentially flow through the second
7 flow path to the production flow system, and may inhibit or prevent flow of the introduced
8 fluid to the first flow path.

9

10 Alternatively, the at least one flow barrier may be a choke valve.

11

12 The valve operable to control the flow of the introduced fluid through the inlet may be
13 located externally to a main body of the apparatus. Alternatively, the valve may be located
14 internally to a main body of the apparatus. The valve may be a controllable valve.

15

16 The apparatus may be operable to transmit a signal to a control module. The control
17 module may be local to the apparatus in use. Alternatively, or in addition, the control
18 module may be remote from the apparatus in use, and may for example be located on a
19 surface vessel.

20

21 The apparatus may be used for preventing or reducing flow of a first treatment chemical
22 into the subsea production flow system. In this application, the inlet may be configured for
23 receiving a second treatment chemical. The apparatus may comprise a first sensor which
24 may be operable to detect a condition indicative of the first treatment chemical in the
25 apparatus and which may transmit a signal to the control module. The valve may be a
26 dosing valve which may be operable to control the flow of the second treatment chemical
27 through the inlet to the subsea production flow system which may be in response to a
28 control signal from the control module. The at least one flow barrier may be disposed
29 between the inlet and the at least one sensor. The at least one sensor may be a pH
30 sensor.

31

32 The apparatus may be used for injecting a gas into the subsea production flow system for
33 a gas lift operation. In this application, the inlet may be configured for receiving gas.

1 The valve may be operable to control the flow of gas through the inlet to the subsea
2 production flow system. The at least one flow barrier may prevent the passage of the gas
3 from the inlet to the subsea well.

4

5 The inlet for receiving the gas may be in the form of a hot stab receptacle which may be
6 configured to receive a hot stab connector. The hot stab connector may be an ROV hot
7 stab connector.

8

9 Alternatively, or in addition, the inlet for receiving gas may be configured to receive gas
10 from one or more gas delivery lines. The gas delivery lines may be provided by an
11 umbilical.

12

13 The second flow path may comprise additional valves and/or flow components required for
14 the gas lift operation. For example, the second flow path may comprise an injection check
15 valve and/or an injection nozzle.

16

17 The second flow path may comprise additional instrumentation for monitoring fluid and/or
18 flow properties such as pressure, temperature, flow rate and fluid composition. The second
19 flow path may comprise, for example, a pressure and temperature transducer (PTT)
20 operable to measure characteristics of the fluid within the apparatus. Alternatively, or in
21 addition, the second flow path comprises a flow meter operable to measure and monitor
22 the properties of production flow in the second flow path following dosing and/or gas
23 injection.

24

25 Instrumentation within the first and/or second flow paths may be operable to feedback to
26 the control module, and dosing rates, gas injection rates or other properties of the flow
27 operation may be adjusted based on feedback from the instrumentation.

28

29 Valves and instrumentation included in the control module may be controlled hydraulically
30 and/or electronically.

31

32 According to a second aspect of the invention, there is provided a method of introducing a
33 fluid to a subsea production flow system, the method comprising:
34 providing an apparatus fluidly connected to a subsea well and a subsea production flow
35 system, the apparatus comprising an inlet for receiving the introduced fluid and at least

1 one flow barrier preventing passage of the introduced fluid from the inlet to the subsea
2 well;
3 flowing a production fluid from the subsea well into the apparatus;
4 controlling flow of the introduced fluid into the apparatus, through the inlet and in to the
5 subsea production flow system; and
6 flowing the production fluid and introduced fluid to the subsea production flow system.

7
8 The method may be for preventing or reducing flow of a first treatment chemical into the
9 subsea production flow system. The method may comprise detecting in the production
10 fluid a condition indicative of a first treatment chemical which may be done by using a first
11 sensor in the apparatus. The introduced fluid may be a second treatment chemical. The
12 method may comprise controlling the flow of the second treatment chemical into the
13 apparatus which may be for the purpose of dosing the production fluid to counteract an
14 effect of the first treatment chemical. The method may comprise flowing the dosed
15 production fluid to the subsea production flow system.

16
17 The condition indicative of a first treatment chemical may be a pH outside of a desired pH
18 range. The condition may be pH lower than a desired threshold.

19
20 The second treatment chemical may be a base substance, and/or an alkaline or caustic
21 chemical selected to raise the pH of the production fluid to above a desired threshold. The
22 second treatment chemical may, for example, be a caustic soda, or another suitable basic
23 chemical.

24
25
26 The method may be for injecting a gas into the subsea production flow system. The
27 introduced fluid may be gas. The method may comprise controlling flow of the gas into the
28 apparatus, through the inlet and in to the subsea production flow system. The method may
29 comprise flowing the production fluid and gas to the subsea production flow system.

30
31 The method may comprise adjusting gas injection rates and/or other properties of the gas
32 injection operation based on feedback from instrumentation within the apparatus.

33
34 The instrumentation may be operable to monitor properties of production fluid in the
35 apparatus, prior to and following gas injection. For example, the instrumentation may be

1 able to monitor the pressure, temperature, flow rate and/or fluid composition of the
2 production fluid.

3

4 Embodiments of the second aspect of the invention may include one or more features of
5 the first aspect of the invention or its embodiments, or vice versa.

6

7 According to a third aspect of the invention, there is provided a system for introducing a
8 fluid to a subsea production flow system, the system comprising:

9 a subsea well;

10 a subsea production flow system;

11 an apparatus fluidly coupling the subsea well to the subsea production flow system via a
12 first flow path, wherein the apparatus further comprises an inlet for receiving the
13 introduced fluid and a second flow path between the inlet and the subsea production flow
14 system;

15 wherein the apparatus further comprises a valve operable to control the flow of the
16 introduced fluid through the inlet to the subsea production flow system; and

17 wherein the apparatus further comprises at least one flow barrier in the first flow path,
18 preventing the passage of the introduced fluid from the inlet to the subsea well.

19

20 The second flow path may connect the inlet to the subsea production flow system via at
21 least a part of the first flow path.

22

23 The apparatus may be connected to an external flowline connector of the flow system or a
24 manifold thereof, at a location selected from the group consisting of: a jumper flow line
25 connector; upstream of a jumper flow line or a section of a jumper flow line; downstream of
26 a jumper flow line or a section of a jumper flow line; a Christmas tree; a subsea collection
27 manifold system; subsea Pipe Line End Manifold (PLEM); a subsea Pipe Line End
28 Termination (PLET); a subsea Flow Line End Termination (FLET); and a subsea in-line tee
29 (ILT). Alternatively, or in addition, the apparatus may be connected (directly or otherwise)
30 to a production riser, such that it is in fluid communication with the production riser.

31

32 The apparatus may be connected to an external flowline connector of any: jumper flow
33 line; section of a jumper flow line; Christmas tree; subsea collection manifold system;
34 subsea Pipe Line End Manifold (PLEM); subsea Pipe Line End Termination (PLET);
35 subsea Flow Line End Termination (FLET); subsea in-line tee (ILT); and production riser.

1 The apparatus may be connected to a flow access apparatus. The flow access apparatus
2 may be connected to a jumper flowline connector in the jumper flowline envelope of a
3 subsea tree and a jumper flowline of the production flow system.

4

5 The flow access apparatus may be connected to an external flowline connector of the flow
6 system or a manifold thereof, at a location selected from the group consisting of: a jumper
7 flow line connector; upstream of a jumper flow line or a section of a jumper flow line;
8 downstream of a jumper flow line or a section of a jumper flow line; a Christmas tree; a
9 subsea collection manifold system; subsea Pipe Line End Manifold (PLEM); a subsea Pipe
10 Line End Termination (PLET); a subsea Flow Line End Termination (FLET); and a subsea
11 in-line tee (ILT). Alternatively, or in addition, the flow access apparatus may be connected
12 (directly or otherwise) to a production riser, such that it is in fluid communication with the
13 production riser.

14

15 The flow access apparatus may be connected to an external flowline connector of any:
16 jumper flow line; section of a jumper flow line; Christmas tree; subsea collection manifold
17 system; subsea Pipe Line End Manifold (PLEM); subsea Pipe Line End Termination
18 (PLET); subsea Flow Line End Termination (FLET); subsea in-line tee (ILT); and
19 production riser

20

21 The apparatus may be fluidly connected to a production riser.

22

23 Embodiments of the third aspect of the invention may include one or more features of the
24 first and second aspects of the invention or their embodiments, or vice versa.

25

26 According to a fourth aspect of the invention, there is provided an apparatus for preventing
27 or reducing flow of a first treatment chemical into a subsea production flow system, the
28 apparatus comprising:

29 a first flow path through the apparatus for fluidly coupling a subsea well to a subsea
30 production flow system;

31 an inlet for receiving a second treatment chemical; and

32 a second flow path fluidly connecting the inlet and the subsea production flow system;

33 a first sensor for detecting a condition indicative of the first treatment chemical in the
34 apparatus and transmitting a signal to a control module; and

1 a dosing valve operable to control the flow of the second treatment chemical through the
2 inlet to the subsea production flow system in response to a control signal from the control
3 module.

4

5 The second flow path may connect the inlet to the subsea production flow system via at
6 least a part of the first flow path.

7

8 Preferably, the apparatus comprises at least one flow barrier in the first flow path,
9 preventing the passage of fluid from the inlet to the subsea well. The at least one flow
10 barrier may be a check valve.

11

12 The at least one flow barrier is preferably disposed between the inlet and the at least one
13 sensor.

14

15 Preferably the sensor is a pH sensor.

16

17 The control module may be local to the apparatus in use. Alternatively, the control module
18 may be remote from the apparatus in use, and may for example be located on a surface
19 vessel.

20

21 Embodiments of the fourth aspect of the invention may include one or more features of the
22 first to third aspects of the invention or their embodiments, or vice versa.

23

24 According to a fifth aspect of the invention, there is provided a method of preventing or
25 reducing flow of a first treatment chemical into a subsea production flow system, the
26 method comprising:

27 flowing a production fluid from a subsea well into an apparatus fluidly connected to the
28 subsea well, and to a subsea production flow system;

29 detecting in the production fluid a condition indicative of a first treatment chemical using a
30 first sensor in the apparatus;

31 controlling the flow of a second treatment chemical into the apparatus to dose the
32 production fluid and counteract an effect of the first treatment chemical; and

33 flowing the dosed production fluid to the subsea production flow system.

34

1 The condition indicative of a first treatment chemical may be a pH outside of a desired pH
2 range. The condition may be pH lower than a desired threshold.

3

4 The second treatment chemical may be a base substance, and/or an alkaline or caustic
5 chemical selected to raise the pH of the production fluid to above a desired threshold. The
6 second treatment chemical may, for example, be a caustic soda, or another suitable basic
7 chemical.

8

9 Embodiments of the fifth aspect of the invention may include one or more features of the
10 first to fourth aspects of the invention or their embodiments, or vice versa.

11

12 According to a sixth aspect of the invention, there is provided a system for preventing or
13 reducing flow of a first treatment chemical into a subsea production flow system, the
14 system comprising:

15 a subsea well;

16 a subsea production flow system;

17 an apparatus fluidly coupling the subsea well to the subsea production flow system via a
18 first flow path, wherein the apparatus further comprises an inlet for receiving a second
19 treatment chemical, and a second flow path between the inlet and the subsea production
20 flow system;

21 wherein the apparatus comprises at least one treatment chemical sensor for detecting a
22 condition indicative of the first treatment chemical in the apparatus and transmitting a
23 signal to a control module; and

24 wherein the apparatus further comprises a dosing valve operable to control the flow of the
25 second treatment chemical through the inlet to the subsea production flow system in
26 response to a control signal from the control module.

27

28

29 The second flow path may connect the inlet to the subsea production flow system via at
30 least a part of the first flow path.

31

32 Embodiments of the sixth aspect of the invention may include one or more features of the
33 first to fifth aspects of the invention or their embodiments, or vice versa.

34

1 According to a seventh aspect of the invention, there is provided an apparatus for injecting
2 a gas into a subsea production flow system for a gas lift operation, the apparatus
3 comprising:
4 a first flow path through the apparatus for fluidly coupling a subsea well to a subsea
5 production flow system;
6 an inlet for receiving the gas;
7 a second flow path fluidly connecting the inlet and the subsea production flow system;
8 a valve operable to control the flow of gas through the inlet to the subsea production flow
9 system; and
10 at least one flow barrier in the first flow path, preventing the passage of the gas from the
11 inlet to the subsea well.

12

13 The second flow path may connect the inlet to the subsea production flow system via at
14 least a part of the first flow path.

15

16 The inlet for receiving the gas may be in the form of a hot stab receptacle which may be
17 configured to receive a hot stab connector. The hot stab connector may be an ROV hot
18 stab connector.

19

20 Alternatively, or in addition, the inlet for receiving gas may be configured to receive gas
21 from one or more gas delivery lines. The gas delivery lines may be provided by an
22 umbilical.

23

24 The second flow path may comprise additional valves and/or flow components required for
25 the gas lift operation. For example, the second flow path may comprise an injection check
26 valve and/or an injection nozzle.

27

28 The second flow path may comprise additional instrumentation for monitoring properties
29 such as pressure, temperature, flow rate and fluid composition. The second flow path may
30 comprise, for example, a pressure and temperature transducer (PTT) operable to measure
31 characteristics of the fluid within the apparatus. Alternatively, or in addition, the second
32 flow path comprises a flow meter operable to measure and monitor the properties of
33 production flow in the second flow path following gas injection.

34

1 Instrumentation within the first and/or second flow paths may be operable to feedback to a
2 control module, and gas injection rates or other properties of the gas injection operation
3 may be adjusted based on feedback from the instrumentation.

4

5 The control module may be local to the apparatus in use. Alternatively, the control module
6 may be remote from the apparatus in use, and may for example be located on a surface
7 vessel.

8

9 Valves and instrumentation included in the control module may be controlled hydraulically
10 and/or electronically.

11

12 The apparatus may be configured to be connected to the subsea production flow system
13 anywhere in the jumper flowline envelope of the flow system.

14

15 The apparatus may be configured to be connected to an external flowline connector of the
16 flow system or a manifold thereof, at a location selected from the group consisting of: a
17 jumper flow line connector; upstream of a jumper flow line or a section of a jumper flow
18 line; downstream of a jumper flow line or a section of a jumper flow line; a Christmas tree;
19 a subsea collection manifold system; subsea Pipe Line End Manifold (PLEM); a subsea
20 Pipe Line End Termination (PLET); a subsea Flow Line End Termination (FLET); and a
21 subsea in-line tee (ILT).

22

23 Alternatively, or in addition, the apparatus may be configured to be connected (directly or
24 otherwise) to a production riser, such that it is in fluid communication with the production
25 riser.

26

27 Embodiments of the seventh aspect of the invention may include one or more features of
28 the first to sixth aspects of the invention or their embodiments, or vice versa.

29

30 According to an eighth aspect of the invention, there is provided a method of injecting a
31 gas into a subsea production flow system, the method comprising:
32 providing an apparatus fluidly connected to a subsea well and a subsea production flow
33 system, the apparatus comprising an inlet for receiving the gas and at least one flow
34 barrier preventing passage of the gas from the inlet to the subsea well;
35 flowing a production fluid from the subsea well into the apparatus;

1 controlling flow of the gas into the apparatus, through the inlet and in to the subsea
2 production flow system; and
3 flowing the production fluid and gas to the subsea production flow system.
4

5 The method may comprise adjusting gas injection rates and/or other properties of the gas
6 injection operation based on feedback from instrumentation within the apparatus.
7

8 The instrumentation may be operable to monitor properties of production fluid in the
9 apparatus, prior to and following gas injection. For example, the instrumentation may be
10 able to monitor the pressure, temperature, flow rate and/or fluid composition of the
11 production fluid.
12

13 Embodiments of the eighth aspect of the invention may include one or more features of the
14 first to seventh aspects of the invention or their embodiments, or vice versa.
15

16 According to a ninth aspect of the invention, there is provided a system for injecting a gas
17 to a subsea production flow system, the system comprising:
18 a subsea well;
19 a subsea production flow system;
20 an apparatus fluidly coupling the subsea well to the subsea production flow system via a
21 first flow path, wherein the apparatus further comprises an inlet for receiving the gas and a
22 second flow path between the inlet and the subsea production flow system;
23 wherein the apparatus further comprises a valve operable to control the flow of the gas
24 through the inlet to the subsea production flow system; and
25 wherein the apparatus further comprises at least one flow barrier in the first flow path,
26 preventing the passage of the gas from the inlet to the subsea well.
27

28
29 The second flow path may connect the inlet to the subsea production flow system via at
30 least a part of the first flow path.
31

32 nThe apparatus may be connected to the subsea production flow system anywhere in the
33 jumper flowline envelope of the flow system.
34

1 The apparatus may be connected to an external flowline connector of the flow system or a
2 manifold thereof, at a location selected from the group consisting of: a jumper flow line
3 connector; upstream of a jumper flow line or a section of a jumper flow line; downstream of
4 a jumper flow line or a section of a jumper flow line; a Christmas tree; a subsea collection
5 manifold system; subsea Pipe Line End Manifold (PLEM); a subsea Pipe Line End
6 Termination (PLET); a subsea Flow Line End Termination (FLET); and a subsea in-line tee
7 (ILT).

8
9 Alternatively, or in addition, the apparatus may be connected (directly or otherwise) to a
10 production riser, such that it is in fluid communication with the production riser.

11
12 Embodiments of the ninth aspect of the invention may include one or more features of the
13 first to eighth aspects of the invention or their embodiments, or vice versa.

14
15 Brief description of the drawings

16
17 There will now be described, by way of example only, various embodiments of the
18 invention with reference to the drawings, of which:

19
20 Figure 1 is a schematic view of a subsea production flow system with an apparatus
21 according to an embodiment of the invention;

22
23 Figure 2 is a schematic view of an apparatus according to an embodiment of the invention;

24
25 Figure 3 is a schematic process and instrumentation diagram of a vessel-controlled
26 system according to an embodiment of the invention;

27
28 Figure 4 is a schematic process and instrumentation diagram of a subsea-controlled
29 system according to an embodiment of the invention;

30
31 Figure 5 is a schematic process and instrumentation diagram of a subsea-controlled
32 system according to an alternative embodiment of the invention;

33
34 Figures 6A and 6B are alternative isometric views of an apparatus in accordance with an
35 embodiment of the invention;

Figure 7 is a schematic process and instrumentation diagram of an apparatus according to an embodiment of the invention;

Figure 8 is a schematic view of an apparatus according to an alternative embodiment of the invention; and

Figure 9 is a schematic view of an apparatus according to a further alternative embodiment of the invention.

Detailed description of preferred embodiments

Referring firstly to Figure 1, there is shown generally at 100 a subsea production flow system. The system comprises a subsea tree 12 on a subsea well 14. The subsea tree 12 has a jumper flowline connector 16, which defines the boundary of the tree envelope, and which conventionally a production jumper flowline would be connected to convey production fluids to the production flow system 18 downstream of the tree 12.

In the configuration shown, a flow access apparatus 20 is connected to the jumper flowline connector 16 in the jumper flowline envelope, between the subsea tree and the jumper flowline of the production flow system. The flow access apparatus 20 is a dual bore access hub of the type described in the applicant's international patent publication number WO 2016/097717, and facilitates fluid intervention to the subsea well and/or production flow system through a single interface 22. In this embodiment, prior to the configuration shown in Figure 1, the flow access apparatus 20 has enabled flow access to the subsea well in a scale squeeze operation, via a dedicated chemical injection module (not shown) connected to the interface 22. The scale squeeze operation has injected a first treatment chemical, which in this case is an acid such hydrochloric acid or hydrofluoric acid, into the subsea well. Subsequent to the treatment operation, the well is shut in, the dedicated chemical injection module (not shown) is removed, and the module 30 is connected to the hub, as shown in Figure 1. The module 30 is connected to a surface vessel 50 or other surface facility by a fluid and communications control umbilical 52, in this case via a subsea module 54 (such that the control umbilical is shown in two sections 52a and 52b).

1 Figure 2 is a schematic view of the module 30. The module comprises a body 31 with a
2 lower interface for coupling the module to the interface 22 of the access apparatus 20. A
3 guide funnel 32 facilitates connection of the module to the interface 22 of the access
4 apparatus. A first bore 33 extends through the body 31 from the lower interface
5 connection to the jumper flowline connector 16. A second bore 34 extends through the
6 body 31 from the lower interface connection to the production flowline 18. The first and
7 second bores are connected to one another via a check valve 38, which permits flow of
8 fluid in the direction from the subsea tree to the production flow system, but prevents flow
9 in the opposing direction. Together the first and second bores define a first flow path
10 through the apparatus for production fluid.

11

12 The body also comprises an inlet 36 to the second bore on the production flow system
13 side of the check valve 38. The inlet 36 enables fluid to be passed through the apparatus
14 and into the production flow system, from a fluid source (not shown) on an opposing side
15 of a dosing valve 40. In this embodiment, the dosing valve 40 is shown externally to the
16 main body 31 of the apparatus, connected by a studded connection 37, but it will be
17 appreciated that in other embodiments in the valve may be internal to the body 31.

18

19 The apparatus also comprises sensor 39, capable of monitoring the fluid in the apparatus,
20 and detecting a characteristic indicative of the presence of a treatment chemical in the
21 fluid. The treatment chemical may be the treatment chemical injected in a previous
22 treatment operation, or a reaction product of the injected chemical. In this case, the
23 sensor is a pH sensor, capable of detecting the pH of the production fluid. The sensor
24 generates an output signal to a control module (not shown). If the control module
25 determines that the pH of the fluid is not within a desired range, for example is too low
26 (acidic) for flow through the production flow system without risk of detrimental effects, the
27 control module generates a signal to open the dosing valve 40 to enable a second
28 treatment chemical to enter the inlet 36 to the production flow. The second treatment
29 chemical is in this case an alkaline or caustic fluid such as caustic soda, which is
30 administered to raise the pH of the fluid to within a desired range. The check valve 38
31 prevents flow of the second treatment chemical to the first bore, at which the pH sensor is
32 located, so that the second treatment chemical does not interfere with the monitoring of
33 the inflowing production fluid.

34

1 It will be appreciated that scale squeeze operations may utilise a range of different
2 chemical treatments including a variety of acids or other solvents, and the invention
3 extends to such embodiments, with appropriate sensors and use of appropriate second
4 treatment chemicals to counteract an adverse condition detected in the fluid.

5
6 Figure 3 is a schematic representation of a system according to an alternative embodiment
7 of the invention. The system, generally shown at 200, is similar to the system 100
8 incorporating the module 30, and will be understood from Figures 1 and 2 and their
9 accompanying description. Like features are given like reference numerals incremented
10 by 100. The system 200 differs from the system 100 in that the module 230 comprises an
11 additional sensor 261 on the production flow system side of the check valve 238, to enable
12 monitoring of a characteristic of the fluid as it passes through the module and after it has
13 been dosed with a second treatment chemical. The module also comprises an additional
14 check valve 262 disposed between the sensor 239 and the check valve 238.

15
16 The system 200 is configured to be controlled remotely from a vessel 50 at surface, via
17 control lines 256, 258, and 260. A signal indicative of adverse fluid characteristics is sent
18 from the sensors 239 and/or 261 to a control module on the vessel, and a control signal is
19 sent from the control module to operate the subsea skid 254 and the dosing valve 240 to
20 deliver the second treatment chemical from the vessel 50 via a flowline or hose
21 252a/252b.

22
23 Figure 4 is a schematic representation of a system according to an alternative embodiment
24 of the invention. The system, generally shown at 300, is similar to the system 200
25 incorporating the module 230, and will be understood from Figures 1 to 3 and their
26 accompanying description. Like features are given like reference numerals incremented
27 by 100. The system 300 differs from the system 200 in that the control module 350 is
28 located locally, in a subsea location at or close to the module 330. The control module
29 350 receives a signal indicative of an adverse condition of the fluid, and controls the
30 dosing valve 340 to enable a counteracting chemical to flow into the production fluid before
31 it enters the production flow system 18.

32
33 Figure 5 is a schematic representation of a system according to an alternative embodiment
34 of the invention. The system, generally shown at 400, is similar to the system 300
35 incorporating the module 330, and will be understood from Figures 1 to 4 and their

1 accompanying description. Like features are given like reference numerals incremented
2 by 100. The system 400 differs from the system 300 in that rather than delivering the
3 second treatment chemical from a flowline or hose from a vessel, the apparatus comprises
4 a reservoir 470 of the second treatment chemical at or near the module 430 in a subsea
5 location.

6
7 It will be appreciated that variations to the control configurations described with reference
8 to Figures 3 to 5 are within the scope of the invention, and include combinations of local
9 and remote control, and control from ROVs, subsea control modules, or other subsea
10 equipment. The control of dosing may be implemented automatically by the control
11 module, or may be user-operated based on signals received from the sensors.

12
13 Figure 6A and 6B are alternative isometric views of an apparatus 500 according to an
14 embodiment of the invention, and show an example of how the module may be physically
15 laid out. Figure 6A shows the module 500 with a blind cap 502 in place, and Figure 6B
16 shows the apparatus with the blind cap removed.

17
18 Figure 7 is a simplified schematic representation of a module 630 according to a further
19 alternative embodiment of the invention. The module 630 is similar to the module 230 and
20 will be understood from Figures 1 to 5 and their accompanying description. Like features
21 are given like reference numerals incremented by 400. For clarity, Figure 7 shows the
22 module 630 only and omits features relating to the wider system (such as the flow access
23 apparatus and the dosing system) and the control system, including a control module,
24 control lines and the source of the treatment chemical. However, it will be appreciated that
25 any of the control configurations and the like, described with reference to the previous
26 drawings, may be used with this embodiment of the invention.

27
28 The module 630 differs from the module 230 in that it comprises a choke valve 641 instead
29 of a check valve. The choke valve 641 is a controllable choke valve which is operable to
30 create a flow restriction and pressure drop in the system, resulting in a favourable flow
31 route for the second treatment chemical upon entry into the module via the dosing valve
32 (not shown). The pressure drop generated by the choke valve 641 causes the second
33 treatment chemical to preferentially flow through the second bore 634 in the production
34 flow system side of the module, and inhibits or prevents flow of the second treatment
35 chemical to the first bore 633.

1
2 Although the choke valve 641 is shown instead of a check valve, it will be appreciated that
3 alternative arrangements of the flow paths within the module 630 - including the provision
4 of additional valves - may be implemented. For example, the choke valve 641 may be
5 provided in an alternative position within the module 630, and/or may be provided
6 alongside one or more check valves. Alternatively, the choke valve 641 may be replaced
7 with a different type of valve or flow restriction as appropriate, to cause preferential flow of
8 the second treatment chemical to the production side.

9
10 Although the foregoing description describes a module for preventing or reducing flow of a
11 treatment chemical into a subsea production flow system, it will be appreciated that a
12 similarly configured module may also be utilised for alternative purposes. For example,
13 Figure 8 shows a module 730 according to a further alternative embodiment of the
14 invention. The module 730 is functionally similar to the module 230, with like features
15 given like reference numerals incremented by 500. The module 730 is shown connected to
16 a dual bore flow access apparatus 20. However, for clarity, Figure 8 omits features
17 relating to the wider flow system. A first bore 733 of the module 730 extends through the
18 body 731 from the lower interface connection to the jumper flowline connector 16 of a
19 subsea Christmas tree and a second bore 734 extends through the body 731 from the
20 lower interface connection to the production flow system 18.

21
22 The module 730 is for use in gas lift operations, to facilitate the injection of gas into the
23 production flow system to aid hydrocarbon recovery. The module 730 also functions to
24 prevent injected gas from entering the subsea well.

25
26 The module 730 comprises an internal valve 740 to control the injection of gas into the
27 production flow system. It will be appreciated this valve may alternatively be external
28 to the body 731 of the module 730 if required. Gas for injecting is supplied to the module
29 730 via a stab connection between a stab receptacle 764 of the module 730 and a stab
30 connector 766. The stab connector may, for example, be a ROV hot stab connector.

31
32 In operation, the valve 740 functions to operably restrict or allow passage of gas through
33 the inlet 736 and into the second bore 734 of production flow, whilst the check valve 738
34 prevents flow of the gas into the first bore 733. The injected gas mixes with the production

1 flow and decreases the density of the production flow entering the production flow system
2 18, thereby aiding and/or increasing production.

3

4 It will be noted that the module 730 optionally also contains sensors, meters and/or other
5 instrumentation 739, 761 for gauging properties and characteristics of the fluid and/or the
6 flow. In this embodiment, 761 is a flow meter used for flow measurement to monitor and
7 assess optimal gas injection rates.

8

9 The module 830 shown in Figure 9 is similar to the module 730 shown in Figure 8.
10 However, the module 830 differs from the module 730 in that it comprises a choke valve
11 841 instead of a check valve. The choke valve 841 is an electrically actuated choke valve
12 operable to create a flow restriction and pressure drop in the system to cause the injected
13 gas to preferentially flow through the second bore 834 in the production flow system side
14 of the module, and inhibits or prevents flow of the injected gas to the first bore 833.

15

16 Although the flow access apparatus 20 has been described as being located on a jumper
17 flowline connector 16 of a subsea tree, it will be appreciated that the flow access
18 apparatus 20 may have an alternative location. For example, the flow access apparatus 20
19 may be configured to be connected to the flow system anywhere in the jumper flowline
20 envelope, between an external flowline connector of a subsea production flow system or a
21 manifold thereof, for example at a location selected from the group consisting of: a jumper
22 flow line connector; upstream of a jumper flow line or a section of a jumper flow line;
23 downstream of a jumper flow line or a section of a jumper flow line; a Christmas tree; a
24 subsea collection manifold system; subsea Pipe Line End Manifold (PLEM); a subsea Pipe
25 Line End Termination (PLET); a subsea Flow Line End Termination (FLET); and a subsea
26 in-line tee (ILT).

27

28 It will also be appreciated that the production flow system 18 downstream of the flow
29 access apparatus 20 may be a production pipeline, a jumper flowline or a flexible flowline.
30 Alternatively, the production flow system 18 downstream of the apparatus 20 may be
31 connected (directly or otherwise) to a production riser.

32

33 For example, referring back to Figures 8a and 8b, it may be desirable to perform a gas lift
34 operation at or near the base of a production riser. The injected gas will decrease the
35 density of the production flow thus aiding and/or increasing recovery up the riser. As such,

1 the flow access apparatus 20 may be located on subsea infrastructure located near the
2 production riser (which, as above, might not be a subsea tree). The injected gas
3 decreases the density of the production flow exiting the module 730 and the flow access
4 apparatus 20 and entering the flow system 18 which, in this alternative case is the
5 production riser.

6

7 The invention provides an apparatus for introducing a fluid into a subsea production flow
8 system, a system and a method of use. The apparatus comprises a first flow path through
9 the apparatus for fluidly coupling a subsea well to a subsea production flow system and an
10 inlet for receiving a fluid. A second flow path fluidly connects the inlet and the subsea
11 production flow system. A valve is operable to control the flow of the fluid through the inlet
12 to the subsea production flow system.

13

14 In one embodiment, the invention provides an apparatus for preventing or reducing flow of
15 a first treatment chemical into a subsea production flow system, a system, and a method
16 of use. The apparatus comprises a first flow path through the apparatus for fluidly
17 coupling a subsea well to a subsea production flow system and an inlet for receiving a
18 second treatment chemical. A second flow path fluidly connects the inlet and the subsea
19 production flow system. A first sensor for detects a condition indicative of the first
20 treatment chemical in the apparatus and transmits a signal to a control module; and a
21 dosing valve is operable to control the flow of the second treatment chemical through the
22 inlet to the subsea production flow system in response to a control signal from the control
23 module. In a preferred embodiment, the sensor is a pH sensor, and on detection of a low
24 pH, an alkaline chemical is dosed into the production fluid to raise the pH to an acceptable
25 level. The invention has particular application to the reduction of flow of acidic production
26 fluid through a production flow system following a scale squeeze operation.

27 In an alternative embodiment, the invention provides an apparatus for injecting a gas into a
28 subsea production flow system, a system, and a method of use. The apparatus comprises
29 a first flow path through the apparatus for fluidly coupling a subsea well to a subsea
30 production flow system and an inlet for receiving the gas. A second flow path fluidly
31 connects the inlet and the subsea production flow system. A valve is operable to control
32 the flow of the gas through the inlet to the subsea production flow system. The invention
33 has particular application to gas lift operations.

34

1 Various modifications to the above-described embodiments may be made within the scope
2 of the invention, and the invention extends to combinations of features other than those
3 expressly recited herein.
4

Claims

1. An apparatus (30, 230, 330, 630, 830) for introducing a fluid into a subsea production flow system, the apparatus comprising:
 - a first flow path through the apparatus for fluidly coupling a subsea well to a subsea production flow system;
 - an inlet (36, 736) for receiving the introduced fluid;
 - a second flow path for fluidly connecting the inlet and the subsea production flow system via at least part of the first flow path;
 - a valve (40, 240, 340, 440, 740) operable to control the flow of the introduced fluid through the inlet to the subsea production flow system; and
 - at least one flow barrier (38, 238, 262, 338, 362, 438, 462, 641, 738, 841) in the first flow path, configured to prevent the passage of the introduced fluid from the inlet to the subsea well.
2. The apparatus (30, 230, 330, 630, 830) according to any preceding claim, wherein the apparatus comprises at least one sensor (39, 239, 261, 339, 361, 439, 461, 639, 661, 739, 761) which is operable to detect a condition indicative of a first treatment chemical in the apparatus and wherein the at least one flow barrier (38, 238, 262, 338, 362, 438, 462, 641, 738, 841) is disposed between the inlet (36, 736) and the at least one sensor (39, 239, 261, 339, 361, 439, 461, 639, 661, 739, 761).
3. The apparatus (30, 230, 330, 630, 830) according to claim 2, wherein the at least one sensor (39, 239, 261, 339, 361, 439, 461, 639, 661, 739, 761) is operable to transmit a signal to a control module (350, 450) and wherein the valve (40, 240, 340, 440, 740) is operable to control the flow of a second treatment chemical through the inlet (36, 736) to the subsea production flow system in response to a control signal from the control module.
4. The apparatus (30, 230, 330, 630, 830) according to any preceding claim, wherein the first and/or second flow path comprises additional instrumentation for monitoring fluid and/or flow properties such as pressure, temperature, flow rate and fluid composition.

- 1 5. The apparatus according to claim 4, wherein the instrumentation within the first
2 and/or second flow paths is operable to feedback to a control module, and wherein
3 properties of the flow operation are operable to be adjusted based on said feedback.
4
- 5 6. A method of introducing a fluid to a subsea production flow system, the method
6 comprising:
7 using an apparatus (30, 230, 330, 630, 830) which fluidly couples a subsea well to a
8 subsea production flow system via a first flow path, the apparatus comprising an inlet
9 (36, 736) for receiving the introduced fluid, a second flow path fluidly connecting the
10 inlet and the subsea production flow system via at least part of the first flow path, a
11 valve (40, 240, 340, 440, 740) operable to control the flow of the introduced fluid
12 through the inlet to the subsea production flow system and at least one flow barrier
13 (38, 238, 262, 338, 362, 438, 462, 641, 738, 841) preventing passage of the
14 introduced fluid from the inlet to the subsea well;
15 flowing a production fluid from the subsea well into the apparatus;
16 controlling flow of the introduced fluid into the apparatus, through the inlet and in to
17 the subsea production flow system; and
18 flowing the production fluid and introduced fluid to the subsea production flow
19 system.
20
- 21 7. The method according to claim 6, comprising preventing or reducing flow of a first
22 treatment chemical into the subsea production flow system.
23
- 24 8. The method according to claim 7, comprising detecting in the production fluid a
25 condition indicative of a first treatment chemical by using at least one sensor (39,
26 239, 261, 339, 361, 439, 461, 639, 661, 739, 761) in the apparatus (30, 230, 330,
27 630, 830).
28
- 29 9. The method according to claim 7 or claim 8, wherein the introduced fluid is a second
30 treatment chemical and the method comprises controlling the flow of the second
31 treatment chemical into the apparatus (30, 230, 330, 630, 830) for the purpose of
32 dosing the production fluid to counteract an effect of the first treatment chemical.
33
- 34 10. The method according to claim 8 or claim 9, wherein the condition indicative of a first
35 treatment chemical is a pH outside of a desired pH range, and wherein the second

1 treatment chemical is a base substance, and/or an alkaline or caustic chemical
2 selected to bring the pH of the production fluid to into a desired range.

3

4 11. The method according to any of claims 8 to 10, comprising transmitting a signal from
5 the at least one sensor to a control module and controlling the valve (40, 240, 340,
6 440, 740) to control the flow of the second treatment chemical through the inlet to the
7 subsea production flow system in response to a control signal from the control
8 module (350, 450).

9

10 12. The method according to claim 6, wherein the introduced fluid is gas, and wherein
11 the method comprises injecting the gas into the subsea production flow system by
12 controlling flow of the gas into the apparatus (30, 230, 330, 630, 830), through the
13 inlet and into the subsea production flow system.

14

15 13. A system for introducing a fluid to a subsea production flow system, the system
16 comprising:
17 a subsea well;
18 a subsea production flow system;
19 an apparatus (30, 230, 330, 630, 830) fluidly coupling the subsea well to the subsea
20 production flow system via a first flow path, wherein the apparatus further comprises
21 an inlet (36, 736) for receiving the introduced fluid, a second flow path fluidly
22 connecting the inlet and the subsea production flow system via at least part of the
23 first flow path;
24 a valve (40, 240, 340, 440, 740) operable to control the flow of the introduced fluid
25 through the inlet to the subsea production flow system; and
26 at least one flow barrier (38, 238, 262, 338, 362, 438, 462, 641, 738, 841) in the first
27 flow path, preventing the passage of the introduced fluid from the inlet to the subsea
28 well.

29

30 14. The system according to claim 13, wherein the apparatus (30, 230, 330, 630, 830) is
31 connected to a flow access apparatus (20).

32

33 15. The system according to claim 14, wherein the apparatus (30, 230, 330, 630, 830)
34 comprises an interface connected to an interface (22) of the flow access apparatus
35 (20), wherein the interface comprises first and second bores, the first bore being

1 fluidly coupled to the subsea well and the second bore being fluidly coupled to the
2 subsea production flow system, and wherein the first flow path connects the first and
3 second bores.

4
5 16. The system according to claim 14 or claim 15, wherein the flow access apparatus is
6 connected to:

7 an external flowline connector of the flow system or a manifold thereof, at a location
8 selected from the group consisting of: a jumper flow line connector; upstream of a
9 jumper flow line or a section of a jumper flow line; downstream of a jumper flow line
10 or a section of a jumper flow line; a Christmas tree; a subsea collection manifold
11 system; subsea Pipe Line End Manifold (PLEM); a subsea Pipe Line End
12 Termination (PLET); a subsea Flow Line End Termination (FLET); and a subsea in
13 line tee (ILT); and
14 a jumper flowline of the production flow system.

15

16 17. The system according to claim 13, wherein the apparatus is fluidly connected to a
17 production riser.