

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 to subsea manifolds, and apparatus, systems and methods for use
5 with subsea manifolds.

6

7 Background to the invention

8

9 In the field of subsea engineering for the hydrocarbon production industry, it is known to
10 provide flow systems comprising manifolds. A subsea manifold may be connected to one
11 or more flowlines coming from or going to other flow infrastructure, for example from or to
12 a subsea well or multiple subsea wells. As such, a typical subsea manifold has a plurality
13 of connectors for the tie-in of the flowlines, which may be, for example, jumper flowlines
14 carrying production fluids from the multiple wells. Fluids which enter a subsea manifold of
15 this type from one or more flowlines are typically then sent onwards from the manifold to a
16 different location. For example, the fluids delivered from several subsea wells may be
17 commingled and sent topsides via one or more flowlines.

18

19 More generally, the term “subsea manifold” may be taken to include a number of different
20 types of subsea infrastructure, including but not limited to a subsea Christmas tree, a
21 subsea collection manifold system, a subsea well gathering manifold, a subsea distributed
22 manifold system (such as an in-line tee (ILT)), a subsea Pipe Line End Manifold (PLEM), a
23 subsea Pipe Line End Termination (PLET) and a subsea Flow Line End Termination
24 (FLET).

25

26 During the development and life-span of subsea hydrocarbon fields, it is often the case
27 that new hydrocarbon discoveries are made and/or further tie-ins to the flow system
28 infrastructure are required. As such, typical subsea well gathering manifolds may be
29 provided with surplus connectors, to accommodate future tie-in requirements. However,
30 such manifolds tend to demand a large initial capital expenditure because they are fully
31 equipped with all of the equipment, instrumentation and valving needed to facilitate the tie-
32 in and production of the future wells.

33

34 Whatever the type of subsea manifold, if the internal equipment, instrumentation and/or
35 valving within the manifold is to fail, in order to repair or replace these parts the entire

1 manifold must be recovered. This typically requires large vessels, is expensive, disruptive
2 and potentially damaging to the surrounding subsea infrastructure, and disruptive to
3 production operations.

4

5 Summary of the invention

6

7 It is amongst the aims and objects of the invention to provide a subsea manifold and
8 method of use which mitigates drawbacks of prior art subsea manifolds and methods of
9 use.

10

11 It is amongst the aims and objects of the invention to provide an apparatus, system and a
12 method of use for providing fluid control, fluid measurement and/or intervention in a flow
13 system of an oil and gas production installation, which is an alternative to the apparatus
14 and methods described in the prior art.

15

16 It is amongst the aims and objects of the invention to provide an apparatus, system and a
17 method of use for providing fluid control, fluid measurement and/or intervention in an oil
18 and gas production installation, which addresses one or more drawbacks of the prior art.

19

20 An object of the invention is to provide a flexible apparatus, system and method of use
21 suitable for use with and/or retrofitting to industry standard or proprietary oil and gas
22 manifolds.

23

24 Further objects and aims of the invention will become apparent from the following
25 description.

26

27 According to a first aspect of the invention, there is provided a subsea manifold configured
28 for connection to a subsea production system, the subsea manifold comprising:
29 at least one removable module;
30 wherein the at least one removable module is configured to perform one or more functions
31 selected from the group comprising: fluid control, fluid sampling, fluid diversion, fluid
32 recovery, fluid injection, fluid circulation, fluid access, fluid measurement, flow
33 measurement and/or fluid metering.

34

1 The subsea manifold may be a subsea manifold selected from the group comprising: a
2 subsea Christmas tree; a subsea collection manifold system; a subsea distributed manifold
3 system such as an in-line tee (ILT); a subsea Pipe Line End Manifold (PLEM); a subsea
4 Pipe Line End Termination (PLET); and a subsea Flow Line End Termination (FLET).

5

6 The manifold may comprise a plurality of removable modules.

7

8 The at least one removable module may be pre-installed on the subsea manifold and left
9 in situ at a subsea location for later performance of a subsea operation.

10

11 The subsea manifold may be provided with alternative and/or additional removable
12 modules. Such additional or alternative modules may be provided to the manifold at any
13 time.

14

15 Fluid measurement may comprise measurement of a temperature and/or a pressure of a
16 fluid.

17 The at least one removable module may be retrievable. Preferably the removable module
18 is retrievable to the surface. The removable module may be replaced with or swapped for
19 an alternative removable module.

20

21 The manifold may comprise one or more fluid access points which may be configured to
22 connect to a removable module. The manifold may comprise flowlines and the one or
23 more fluid access points may be in fluid communication with the flowlines.

24

25 The one or more fluid access points may be provided with flow caps when not in use (i.e.
26 when not currently being used to accommodate or receive a removable module).

27

28 The one or more fluid access points may be single bore fluid access points. Alternatively,
29 or in addition, the one or more fluid access points may be dual bore and/or a multi-bore
30 fluid access points.

31

32 The removable module may comprise a number of bores which corresponds to the
33 number of bores of the fluid access point to which it is required to connect. Multiple
34 removable modules may be provided with alternative bore configurations for multiple fluid
35 access points of complimentary bore configurations.

1

2 The removable module may comprise a connector configured to be connected to the
3 subsea production flow system. The connector may be configured to be connected to a
4 flowline of the subsea production flow system (such as a jumper flowline).

5

6 According to a second aspect of the invention there is provided a subsea manifold for a
7 subsea oil and gas production system, the subsea manifold comprising:

8 at least one connection location for a subsea well;

9 at least one outlet; and

10 at least one fluid access point between the connection location and the outlet;

11 wherein the manifold structure defines a first flow path between the connection location

12 and the at least one access point and a second flow path between the at least one access

13 point and the outlet; and

14 wherein the at least one access point is configured to receive a removable module.

15

16 The at least one fluid access point may be a single bore access point. Alternatively, or in

17 addition, the at least one access point may be a dual bore and/or a multi-bore access

18 point.

19

20 Embodiments of the second aspect of the invention may include one or more features of

21 the first aspect of the invention or its embodiments, or vice versa.

22

23 According to a third aspect of the invention there is provided a removable module for a

24 subsea manifold of a subsea production system, the removable module comprising:

25 at least one connector configured to connect the module to the subsea manifold;

26 wherein the removable module is configured to perform a function selected from the group

27 comprising: fluid control, fluid sampling, fluid diversion, fluid recovery, fluid injection, fluid

28 circulation, fluid access, fluid measurement, flow measurement and/or fluid metering.

29

30 The removable module may comprise an external connector configured to be connected to

31 the subsea production flow system.

32

33 The external connector may be configured to be connected to a flowline of the subsea

34 production flow system (such as a jumper flowline).

35

1 The external connector may be operable to route production flow from the manifold
2 onwards, into the production flow system.

3
4 Alternatively, or in addition, the removable module may comprise a plurality of connectors
5 configured to connect the module to the subsea manifold, such that the module may be in
6 fluid communication with one or more flow paths within the manifold and much that the
7 module may receive flow from and/or direct flow back into the manifold.

8
9 Embodiments of the third aspect of the invention may include one or more features of the
10 first aspect or the second aspect of the invention or their embodiments, or vice versa.

11
12 According to a fourth aspect of the invention there is provided a removable module for a
13 subsea manifold of a subsea oil and gas production system, the removable module
14 comprising:
15 a body; and
16 at least one connector configured to connect the removable module to the subsea
17 manifold;
18 wherein the body defines at least one flow path from the at least one connector configured
19 to be in fluid communication with one or more flow paths of the subsea manifold.

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 subsea oil and gas
25 production installation, the installation comprising:
26 a subsea production system;
27 a subsea manifold defining one or more flow paths and comprising at least one connection
28 location for the subsea production system and at least one fluid access point; and
29 a removable module;
30 wherein the subsea manifold is fluidly connected to the subsea production system at the at
31 least one connection location;
32 wherein the removable module is connected to the at least one fluid access point of the
33 subsea manifold; and
34 wherein the at subsea production system and the removable module are each in fluid
35 communication with a flow path of the one or more flow paths.

1
2 Embodiments of the fifth aspect of the invention may include one or more features of the
3 first to fourth aspects of the invention or their embodiments, or vice versa.

4
5 According to a sixth aspect of the invention, there is provided a subsea oil and gas
6 production installation, the installation comprising:
7 at least one subsea well;
8 a subsea manifold defining one or more flow paths and comprising at least one connection
9 location for a subsea well and at least one fluid access point; and
10 a removable module;
11 wherein the at least one subsea well is fluidly connected to the subsea manifold at the at
12 least one connection location;
13 wherein the removable module is connected to the at least one fluid access point of the
14 subsea manifold; and
15 wherein the at least one subsea well and the removable module are each in fluid
16 communication with a flow path of the one or more flow paths.

17
18 Embodiments of the sixth aspect of the invention may include one or more features of the
19 first to fifth aspects of the invention or their embodiments, or vice versa.

20
21 According to a seventh embodiment of the invention, there is provided a method of
22 installing a removable module to a pre-installed subsea manifold, the method comprising:
23 providing a pre-installed subsea manifold comprising a connector connected to a pre-
24 installed flow component, flow line, module or piece of equipment; and
25 providing a removable module comprising at least one connector.
26 removing the pre-installed flow component, flow line, module or piece of equipment from
27 the connector of the subsea manifold; and
28 coupling the at least one connector of the removable module to the connector of the
29 subsea manifold.

30
31 Embodiments of the seventh aspect of the invention may include one or more features of
32 the first to sixth aspects of the invention or their embodiments, or vice versa.

33
34 According to an eighth embodiment of the invention, there is provided a method of
35 installing a removable module to a pre-installed subsea manifold, the method comprising:

1 providing a pre-installed subsea manifold comprising a connector connected to a pre-
2 installed flowline; and
3 providing a removable module comprising at least two connectors;
4 removing the pre-installed flowline from the connector of the subsea manifold;
5 coupling a first connector of the at least two connectors of the removable module to the
6 connector of the subsea manifold; and
7 coupling the pre-installed flowline to a second connector of the at least two connectors of
8 the removable module.

9
10 The pre-installed flowline may be a production flowline and may be an export flowline.
11 More specifically, the pre-installed flowline may be a flexible or a rigid jumper flowline.

12
13 The removable module may be configured to perform one or more functions selected from
14 the group comprising: fluid control, fluid sampling, fluid diversion, fluid recovery, fluid
15 injection, fluid circulation, fluid access, fluid measurement, flow measurement and/or fluid
16 metering.

17
18 The removable module may comprise a flow path between the at least two connectors.

19
20 The removable module may be a fluid and/or a flow measurement removable module. The
21 removable module may comprise transducers (or sensors) for measuring fluid properties
22 such as pressure and/or temperature and/or for measuring properties such as flow rate.
23 Such transducers (or sensors) may be in direct communication with the flow path of the
24 retrievable module.

25
26 Alternatively, or in addition, the removable module may not perform any of the above
27 functions. Instead, the removable module may act as a spacer module which includes a
28 flow path between its at least two connectors which may allow fluid to flow therethrough.

29
30 The pre-installed flowline may be connected to an outlet connector of the subsea manifold.
31 The method may comprise installing the removable module on the outlet connector of the
32 subsea manifold.

33

1 The pre-installed flowline may be connected to an inlet connector of the subsea manifold.
2 The method may comprise installing the removable module on the inlet connector of the
3 subsea manifold.

4
5 Embodiments of the eighth aspect of the invention may include one or more features of the
6 first to seventh aspects of the invention or their embodiments, or vice versa.

7
8 According to a ninth aspect of the invention there is provided a subsea manifold for a
9 subsea oil and gas production flow system, the subsea manifold comprising:
10 at first connector configured to be fluidly connected to a subsea well;
11 a second connector configured to be fluidly connected to the subsea production flow
12 system;
13 a flowline header in fluid communication with the second connector; and
14 a fluid access point located between the first connector and the flowline header and having
15 first and second flow access openings;
16 wherein the manifold structure defines a first flow path between the first connector and the
17 first flow access opening of the fluid access point and a second flow path between the
18 second flow access opening of the fluid access point and the flowline header;
19 wherein the fluid access point is configured to be connected to a removable module
20 comprising a flow path for connecting the first and second fluid access openings such that
21 the subsea well and the subsea production flow system are fluidly connected by the
22 removable module.

23
24 The subsea manifold may be a subsea Christmas tree, a subsea collection manifold
25 system, a subsea well gathering manifold, a subsea distributed manifold system (such as
26 an in-line tee (ILT)), a subsea Pipe Line End Manifold (PLEM), a subsea Pipe Line End
27 Termination (PLET) and a subsea Flow Line End Termination (FLET).

28
29 The first connector may be configured to be connected to a flowline (such as a jumper
30 flowline) to fluidly connect it to the subsea well. Various flow components (such as
31 flowlines and connectors) may be positioned between the first connector and the subsea
32 well.

33
34 The first connector may be configured to receive production fluid from a subsea well. The
35 first connector may be configured to route a fluid into the subsea well. The first connector

1 may be configured to deliver gas into the subsea well, for the execution of gas lift
2 operations.

3

4 The manifold may comprise additional connectors configured to be fluidly connected to
5 additional subsea wells.

6

7 The second connector may be configured to be fluidly connected to a flowline of the
8 subsea production flow system (such as a jumper flowline). The second connector may be
9 configured to be connected to an export production flowline of the flow system which may
10 transport production fluid to the surface. The second connector may be configured to be
11 connected to a gas delivery flowline.

12

13 The manifold may comprise additional connectors configured to be connected to the
14 subsea production flow system.

15

16 The flowline header may be a production flowline header. Alternatively, the flowline header
17 may be a gas lift flowline, also referred to throughout as a gas lift header or a gas lift
18 flowline header. The manifold may comprise a plurality of flowline headers, and the
19 plurality of flowline headers may comprise production headers, gas lift headers or a
20 combination of production headers and gas lift headers.

21

22 The fluid access point comprising first and second flow access openings may be referred
23 to as a dual bore fluid access point. The fluid access point may comprise more than two
24 flow access openings and may be a multi-bore fluid access point.

25

26 The manifold may comprise additional fluid access points. The manifold may comprise
27 fluid access points which may provide dual bore or multi-bore access to a flowline header.

28

29 The fluid access point or points may be provided with flow caps when not in use (i.e. when
30 not currently being used to accommodate or be connected to a removable module). In this
31 state, and when no removable modules are present, there cannot be flow between a
32 subsea well and a flowline header of the manifold because no flow path exists between
33 them. The flow path or paths that links these components is provided by the removable
34 module(s).

35

1 The removable module may comprise additional flow paths. The flow path or paths of the
2 removable module may comprise one or more valves. The removable module may
3 selectively fluidly connect the subsea well and the subsea production flow system by
4 operation of the one or more valves provided in the flow path or paths of the removable
5 module.

6
7 The removable module may comprise equipment or instrumentation which may be
8 operable to monitor the properties of the fluid flowing therethrough (such as transducers
9 and/or flow meters). The removable module may comprise one or more fluid access points
10 in fluid communication with its flow path and/or one of its paths. The one or more fluid
11 access points may provide a location for accessing the fluid in the manifold and hence the
12 subsea well and/or production system to perform fluid intervention operations.

13
14 The manifold may comprise a third connector configured to be fluidly connected to the
15 subsea production flow system. The manifold may comprise a second flowline header in
16 communication with the third connector. The fluid access point may comprise a third flow
17 access opening. The manifold may define a third flow path between the third flow access
18 opening of the fluid access point and the second flowline header. The fluid access point
19 may be configured to be connected to a removable module comprising a first flow path for
20 connecting the first and second fluid access openings such that the subsea well and the
21 first flowline header are fluidly connected by the first flow path of the removable module
22 and a second flow path for connecting the first and third fluid access openings such that
23 the subsea well and the second flowline header are fluidly connected by the second flow
24 path of the removable module. The first and second flow paths of the removable module
25 may be fluidly connected.

26
27 The manifold may comprise a third connector configured to be fluidly connected to the
28 subsea well. The manifold may comprise a fourth connector configured to be fluidly
29 connected to the subsea production flow system. The manifold may comprise a second
30 flowline header in communication with the fourth connector. The fluid access point may
31 comprise third and fourth flow access openings. The manifold may define a third flow path
32 between the third connector and the third flow access opening of the fluid access point and
33 a fourth flow path between the fourth flow access opening of the fluid access point and the
34 second flowline header. The fluid access point may be configured to be connected to a
35 removable module comprising a first flow path for connecting the first and second fluid

1 access openings such that the subsea well and the first flowline header are fluidly
2 connected by the first flow path of the removable module and a second flow path for
3 connecting the third and fourth fluid access openings such that the subsea well and the
4 second flowline header are fluidly connected by the second flow path of the removable
5 module. The first flowline header may be a production flowline header and the second
6 flowline header may be a gas lift flowline header.

7

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

10

11 According to a tenth aspect of the invention there is provided a removable module for
12 fluidly connecting flow paths within a subsea manifold of a subsea oil and gas production
13 system, the removable module comprising:

14 a body;

15 a first connector; and

16 a second connector;

17 wherein the first and second connectors are configured to be connected to first and
18 second flow access openings of an access point of the subsea manifold, respectively; and
19 wherein the body defines a flow path between the first connector and the second
20 connector.

21

22 The removable module may comprise additional connectors. The removable module may
23 comprise additional flow paths. The flow path or paths of the removable module may
24 comprise one or more valves. The removable module may selectively fluidly connect a
25 subsea well and a subsea production flow system by operation of the one or more valves
26 provided in the flow path or paths of the removable module.

27

28 The removable module may comprise equipment or instrumentation which may be
29 operable to monitor the properties of the fluid flowing therethrough (such as transducers
30 and/or flow meters). The removable module may comprise one or more fluid access points
31 in fluid communication with its flow path and/or one of its flow paths. The one or more fluid
32 access points may provide a location for accessing the fluid in the manifold and hence
33 may provide access to the subsea well and/or the subsea production system to perform
34 fluid intervention operations.

35

1 Embodiments of the tenth aspect of the invention may include one or more features of the
2 first to ninth aspects of the invention or their embodiments, or vice versa.

3

4 According to an eleventh aspect of the invention, there is provided a subsea oil and gas
5 production installation, the installation comprising:

6 at least one subsea well and a subsea production flow system;

7 a subsea manifold according to the ninth aspect of the invention; and

8 a removable module;

9 wherein the first connector of the subsea manifold is fluidly connected to the subsea well
10 and the second connector of the subsea manifold is fluidly connected to the subsea
11 production flow system;

12 wherein the removable module comprises a first connector connected to the first flow
13 access opening of the fluid access point of the manifold and a second connector

14 connected to the second opening of the fluid access point of the manifold;

15 wherein the removable module defines a flow path between its first and second connectors
16 such that the subsea well and the subsea production flow system are fluidly connected by
17 the removable module.

18

19 Embodiments of the eleventh aspect of the invention may include one or more features of
20 the first to tenth aspects of the invention or their embodiments, or vice versa.

21

22 According to a twelfth aspect of the invention, there is provided a method of controlling
23 flow between a subsea well and a subsea production system, the method comprising:

24 providing a subsea oil and gas production installation according to the eleventh aspect of
25 the invention, wherein the removable module comprises at least one valve in the flow path
26 between its first and second connectors;

27 operating the at least one valve to selectively permit fluid to flow from the subsea well to
28 the subsea production flow system and/or from the subsea production flow system to the
29 subsea well.

30

31 The flowline header may be a production flowline header and the method may comprise
32 operating the at least one valve to control flow of production fluid from the subsea well to
33 the production flowline header and subsea production system.

34

1 Alternatively, or in addition, the flowline header may be a gas lift flowline header and the
2 method may comprise operating the at least one valve to control flow of gas flow from the
3 gas lift flowline header to the subsea well.

4

5 The manifold may comprise a third connector configured to be fluidly connected to the
6 subsea production flow system and a second flowline header in communication with the
7 third connector. The first and second flowline headers may be production flowline headers.
8 The fluid access point may comprise a third flow access opening and the manifold may
9 define a third flow path between the third flow access opening of the fluid access point and
10 the second flowline header. The removable module may comprise a second flow path for
11 connecting the first and third fluid access openings such that the subsea well and the
12 second flowline header are fluidly connected by the second flow path of the removable
13 module. The second flow path may comprise at least one valve. The method may
14 comprise operating the at least one valve in the first flow path of the removable module
15 and/or the at least one valve in the second flow path of the removable module to control
16 whether fluid from the subsea well flows into the first and/or the second production flowline
17 headers.

18

19 The manifold may comprise a third connector configured to be fluidly connected to the
20 subsea well and a fourth connector configured to be fluidly connected to the subsea
21 production flow system. The first flowline header may be a production flowline header and
22 the manifold may comprise a second flowline header in communication with the fourth
23 connector. The second flowline header may be a gas lift flowline header. The fluid access
24 point may comprise third and fourth flow access openings and the manifold may define a
25 third flow path between the third connector and the third flow access opening and a fourth
26 flow path between the fourth flow access opening and the second flowline header. The
27 removable module may comprise a second flow path for connecting the third and fourth
28 fluid access openings such that the subsea well and the second flowline header are fluidly
29 connected by the second flow path of the removable module. The method may comprise
30 operating the at least one valve in the first flow path of the removable module to selectively
31 permit production fluid to flow from the subsea well to the subsea production flow system
32 via the production flowline header. The second flow path may comprise at least one valve,
33 and the method may comprise operating the at least one valve in the second flow path of
34 the removable module to selectively control the flow of gas flow from the gas lift flowline
35 header to the subsea well.

1
2 Embodiments of the twelfth aspect of the invention may include one or more features of
3 the first to eleventh aspects of the invention or their embodiments, or vice versa.
4
5 According to a thirteenth aspect of the invention, there is provided a method of connecting
6 a new subsea well to a subsea production system, the method comprising:
7 providing a subsea well, a subsea production flow system and a subsea manifold
8 according to the ninth aspect of the invention;
9 wherein second connector of the subsea manifold is fluidly connected to the subsea
10 production flow system; and
11 wherein the fluid access point of the subsea manifold is provided with a flow cap;
12 fluidly connecting the subsea well to the first connector of the subsea manifold;
13 removing the flow cap from the fluid access point of the subsea manifold; and
14 connecting a removable module according to the tenth aspect of the invention to the fluid
15 access point of the module such that the subsea well and the subsea production flow
16 system are fluidly connected by the removable module.

17
18 Embodiments of the thirteenth aspect of the invention may include one or more features of
19 the first to twelfth aspects of the invention or their embodiments, or vice versa.

20

21 Brief description of the drawings

22

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

25

26 Figure 1 is a schematic side view of a subsea production system according to a first
27 embodiment of the invention;

28

29 Figures 2A and 2B are schematic plan views of a subsea manifold according to an
30 alternative embodiment of the invention;

31

32 Figure 2C is a schematic view of a removable module according to an alternative
33 embodiment of the invention;

34

35 Figures 3A is a schematic plan view of a subsea manifold according to an alternative
36 embodiment of the invention;

1

2 Figure 3B is a schematic view of a removable module according to an alternative
3 embodiment of the invention;

4

5 Figures 4A is a schematic plan view of a subsea manifold according to an alternative
6 embodiment of the invention;

7

8 Figure 4B is a schematic view of a removable module according to an alternative
9 embodiment of the invention;

10

11 Figure 5 is a schematic side view of a subsea production system according to a first
12 embodiment of the invention; and

13

14 Figures 6A to 6C are schematic side views of a subsea production system according to a
15 first embodiment of the invention.

16

17 Detailed description of preferred embodiments

18

19 Referring firstly to Figure 1, there is shown, generally at 10, a subsea production manifold.
20 The manifold 10 comprises a main manifold structure 12 and a removable module 14.

21

22 The main manifold structure 12 is a typical base manifold structure including one or more
23 subsea well tie-in connection locations, a series of internal flowlines, and one or more
24 outlets for production fluid to exit the manifold. The manifold 10 in question also includes
25 an arrangement of valves.

26

27 One of the subsea well tie-in connection locations is shown at X1. Here, the manifold 10
28 receives production fluid from a subsea Christmas tree 16 (not shown) of a subsea well. In
29 addition, a single-bore flow outlet connector is shown at 18. However, it will be appreciated
30 that numerous outlets and/or access points may be provided on the manifold which may
31 also comprise dual-bore and/or multi-bore arrangements.

32

33 Typical subsea production manifolds contain instrumentation for monitoring the properties
34 of the production fluid flowing therethrough (for example, pressure transducers for
35 monitoring pressure, temperature transducers for monitoring temperature, and flow meters

1 for monitoring flow rate, amongst other things). However, such instrumentation has a
2 tendency to fail and/or has a generally shorter life-span than that of the manifold, and in
3 order to repair or replace the instrumentation, it would be necessary to recover the entire
4 manifold in an operation which would cause substantial disruption to the surrounding
5 subsea production system and infrastructure.

6

7 Therefore, it is desirable to be able to provide this functionality in removeable modules
8 which can be individually recovered for repair or replacement should a failure occur.

9

10 Figure 1 shows, in dashed lines at 20, the location of pressure/temperature transducers
11 within the manifold 10 which were used to take pressure and temperature measurements
12 of the production fluid. However, in the present embodiment of the invention, the
13 transducers 20 have failed and are unable to perform their function as intended. As such,
14 this functionality has been added out with to the main manifold structure 12 and provided
15 instead in removable module 14.

16

17 Following an operation to lift the pre-existing rigid jumper flowline 26 from the outlet
18 connector 18 of the manifold, the removable module 14 is installed. The removable
19 module 14 has been landed on and connected to the manifold at the outlet connector 18,
20 such that in use production fluid flows through the module 14 upon exiting the main
21 manifold structure 12. The module 14 defines a single flow bore between upper and lower
22 connectors 23, 24, respectively, and pressure/temperature transducers 22 in
23 communication with the flow bore. Therefore, the module 14 provides the measurement
24 functionality which would, in a typical working manifold, be provided within the main
25 manifold structure. The upper connector 24 of the module 14 is substantially identical to
26 the outlet connector 18 of the manifold 10 itself, such that an onward flowline - which is, in
27 this case, a rigid jumper flowline 26 - can connect to the module 14 in the same manner as
28 it would connect to the manifold 18. This avoids the requirement for modifications to be
29 made to the production system flow infrastructure, thus saving time and expense.

30

31 In the configuration shown in Figure 1, production flow is routed through the rigid jumper
32 flowline 26 upon exiting the manifold 10, and in to a further manifold 10'. The further
33 manifold 10' is a Pipe Line End Termination (PLET) and comprises a main manifold
34 structure 12' and removable module 14'. The removable module 14' differs from the
35 module 14 in that it provides only a single flow bore between its upper and lower

1 connectors, with no additional functionality. The purpose of the module 14 is simply to act
2 as a spacer between the manifold 10' and the rigid flowline 26 and is required in this
3 instance for flowline geometry reasons due to the addition of the transducer module 14.

4
5 Referring now to Figure 2A there is shown, generally at 110, a subsea well gathering
6 manifold comprising a main manifold structure 112 and a one or more removable modules.
7 The main manifold structure 112 is a typical, passive base structure which includes only
8 the necessary piping and flowline headers for the connection and tie-in of multiple subsea
9 wells, and for onward transportation from the manifold of production fluid to the surface
10 and/or to a storage or processing facility.

11
12 The manifold 110 is a so-called "twin header" manifold, which comprises two main
13 production flowline headers 130a and 130b. Production fluid from one or more subsea
14 wells which are connected to the manifold 110 is operable to join and flow through either
15 or both of the production flowline headers 130a, 130b. The production flowline headers
16 130a, 130b of the manifold 110 may also be connected to and/or continuous with incoming
17 production flowlines (not shown) which flow into the manifold 110 in the direction of arrows
18 A. Flow from the wells and the production flowline headers 130a, 130b exits the manifold
19 through the production flowline headers 130a, 130b in the direction of arrows A', into one
20 or more export production flowlines (not shown) which transport the fluid to the surface
21 and/or for onward storage or processing. The manifold also comprises a gas lift flowline
22 header 132 into which gas can be delivered from the surface and/or from a storage or
23 injection facility to the manifold 110 - and subsequently into one or more of the subsea
24 wells which are connected to the manifold 110 - for gas lift operations to assist with the
25 recovery of hydrocarbons.

26
27 In the configuration shown, the manifold 110 has the capacity to be connected to up to four
28 subsea wells. The four subsea well tie-in connection locations are shown generally at X1,
29 X2, X3 and X4. Each connection location X1, X2, X3 and X4 comprises two flowline
30 connectors: a connector 134 to receive production fluid from the subsea tree of a subsea
31 well (either directly or via one or more flowlines and/or additional subsea infrastructure)
32 and a connector 136 for the delivery of gas to a subsea well for gas lift operations. In
33 Figure 2A, the connection locations X2, X3 and X4 are shown with flow caps installed
34 thereon, as they are not connected to any wells. As such, there can be no flow from
35 connection locations X2, X3 or X4 to any of the flowline headers, because no flow path

1 presently exists between them. The connector 136 of connection location X1 has also
2 been provided with a flow cap. However, the connector 134 of connection location X1 is
3 connected to a subsea Christmas tree of a first subsea well (not shown) such that the
4 manifold 110 can receive production fluid flowing from the well. As the connector 136 has
5 been capped, the subsea Christmas tree and well in question are not currently engaged
6 for gas lift operations.

7
8 In use, production fluid which flows into the manifold 10 from one or more subsea wells via
9 the connectors 134 at connection locations X1, X2, X3 and X4 will be routed into either (or
10 both) of the production flowline headers 130a, 130a by removable modules on the main
11 manifold structure 112 (described in more detail below). This may also be assisted by an
12 arrangement of valves provided in the removable modules. In the absence of the
13 removable modules, no flow path exists between the subsea wells and the production
14 headers.

15
16 Likewise, gas which flows into the manifold 110 is directed from the gas lift flowline header
17 132 and into one or more subsea wells via the connectors 136 by an arrangement of
18 removable modules (not currently shown in this Figure) on the main manifold structure 112
19 at access points 139 (currently provided with flow caps) and valves provided therein.
20 Dashed lines 135' have been included to provide an indication of how and where such
21 removable modules would attach to the manifold structure 112. Again, without the
22 removable modules there is no flow path between the subsea wells and the header
23 flowlines within the manifold.

24
25 As mentioned above, the valves of the manifold 110 which are required for routing the
26 production fluid from the wells and into the production flowline headers 130a, 130b are not
27 provided within the main manifold structure 112. Instead, they are provided in removable
28 modules which can be landed on and connected to the manifold structure 112 at discrete
29 access points 137 (and 137'). Most of these access points are currently shown provided
30 with flow caps at 137' and dashed lines 138' have been included to provide an indication of
31 how and where some of these removable modules would attach to the manifold structure
32 112.

33
34 As a first well is connected to the connector 134 of connection location X1, routing of the
35 production fluid from this well, through the manifold, will be described to provide an

1 example of how the manifold works in use. Production fluid from the well enters the
2 manifold 110 at the connector 134 and a multi-bore removable module 138 containing the
3 required valves is provided on access point 137. The valves within this module 138 are
4 operable to route production flow to production flowline header 130a, production flowline
5 header 130b, or both. In figure 2A, the access point 137 has three flow access bores /
6 connectors and the removable module 138 is also provided with three flow access bores /
7 connectors which correspond with the access point 137. However, in alternative
8 arrangements of the invention, a removable module with a different number of access
9 bores to an access point may be provided. For example, a removable module having two
10 access bores corresponding to only two of the access bores of a three bore access point
11 137 could be provided. In this case, the module might contain a flow cap or blank to shut
12 off the third unused module. This sort of arrangement may be provided when production is
13 only required through one of the production headers.

14

15 In some embodiments, the connection locations for the subsea wells may be provided
16 directly on the removable modules, instead of on the manifold (or a combination of these
17 two arrangements may be provided) and the removable modules may function to route
18 said flow into or from the flowline headers as otherwise described throughout.

19

20 In this example, the valves of module 138 are configured to route production flow to
21 production flowline header 130a. Flow from the well connected at connection location X1
22 flows into the flowline header 130a in the manner described, by operation of the valves,
23 and continues along the production header until it reaches arrives at a flow access point
24 140 on the flowline header 130a. 140 is a dual-bore access point which facilitates the
25 landing and connection of dual-bore removable module 142. This module contains
26 instrumentation for measuring the temperature and the pressure of the production fluid
27 flowing within flowline header 130a, as well as a number of valves.

28

29 Although only the provision of valves and instrumentation is described above, any
30 additional flow intervention, measuring and control instrumentation and/or equipment
31 required by the manifold may also be provided in this way (that is, not as part of the main
32 manifold structure, but in removable modules).

33

34 Therefore, unlike typical subsea oil and gas manifolds, the manifold 110 does not include
35 any valves, sensors, other instrumentation or equipment. Instead, these functional

1 elements are provided separately, integrated into one or more removable modules which
2 can be landed on and connected to the manifold at various locations.

3

4 By providing valving, instrumentation and other equipment in removable modules, instead
5 of being integral to the manifold, a number of advantages are realised. For example, this
6 allows for the provision of a simple, standard manifold structure which can be modified
7 depending on desired functions or requirements by selecting appropriate removable
8 modules for connection to the manifold. In addition, the function of such a manifold can be
9 altered at any time by changing the removable modules connected to it. This can be done
10 without disturbing the manifold itself, and without disturbing the greater flow system to
11 which it is connected.

12

13 In situations in which, initially, only one or a small number of wells are to be connected to
14 the manifold, the manifold can be populated with removable modules containing the
15 valving, instrumentation and equipment only required for this precise number of wells. In
16 this way, initial capital expenditure can be reduced, yet the option to further populate the
17 manifold and tie-in additional subsea wells in the future remains open.

18

19 With the functional elements of the manifold being provided in removable modules, repair
20 and replacement is also made simpler, easier and cheaper. For example, specific modules
21 can be retrieved, repaired and/or replaced where necessary without having to alter the
22 entire manifold structure.

23

24 This also allows for a change in purpose or functionality and provides the flexibility to
25 integrate emerging technologies into the flow system in the future, which could aid with
26 reservoir management and increased recovery.

27

28 Referring now to Figure 2B, the same manifold 110 of Figure 2A is shown. However, two
29 wells have now been connected to the manifold 110 at connection locations X1 and X2.
30 The wells have been connected using both connectors 134 and 136 at each connection
31 location, and the manifold structure 112 has been populated with removable modules at
32 the X1 and X2 connection location access points 137, 139 containing the necessary
33 valving and equipment required to send production fluid from the wells onward to the
34 surface and/or for storage or processing and the necessary valving required to facilitate

1 the delivery of gas for a gas lift operation to either or both of the wells connected at X1
2 and/or X2.

3
4 Fluid is produced from the wells in the same manner that is described with reference to
5 Figure 2A. In addition, gas flowing in the manifold can now be directed from the gas lift
6 flowline header 132 and into the subsea wells connected at locations X1 and X2, via the
7 connectors 136, by the arrangement of valves provided in removable modules 135.

8
9 The gas lift flowline header comprises a dual bore flow access point 144, similar to the
10 access point 140 and 140' on the production flowline headers 130a and 130b. Access
11 point 144 facilitates the landing and connection of dual-bore removable module 146 to the
12 manifold structure 112. Again, like the module 142, this module contains instrumentation
13 for measuring the temperature and the pressure of the gas flowing into the gas lift flowline
14 header 132 of the manifold, as well as two valves.

15
16 In Figure 2B, the manifold has also been provided with an additional removable module
17 upon a single bore access point 148, which is in fluid communication with production
18 flowline header 130a. The additional module 150 is a chemical injection module
19 comprising three main injection flowlines 151a, 151b and 151c through which chemicals
20 can be introduced to the production flowline header 130a. Valves contained within the
21 module 150 can control which (if any) injection flowlines are brought into fluid
22 communication with the flowline header 130a in order to carry out chemical injection
23 operations as and when required. The addition of such a module may only be temporary
24 and may only occur as and when required.

25
26 As the modules of the manifold 110 can be removed and replaced with relative ease, the
27 functionality of the manifold 110 can be tailored and enhanced by simply adding, removing
28 or swapping a module, as applicable. For example, Figure 2C shows an alternative
29 module 152 which could be used in place of the multi-bore removable module 138 shown
30 in Figures 2A and 2B, which is operable to route production fluid from one or more wells to
31 either or both of the production headers. The module 152 differs from the module 138 in
32 that it also comprises a multi-phase flow meter 154 to provide the manifold with the
33 additional functionality of performing flow rate measurements for individual phases of the
34 production fluid.

35

1 Manifolds can be provided with a wide range of further alternative modules. For example,
2 a manifold may be provided with a module which has the sole purpose of taking fluid
3 and/or flow measurements (such as temperature and pressure measurements and/or flow
4 rate measurements), or a multi-purpose module which is able to fulfil a fluid and/or flow
5 measurement functionality whilst also providing a flow access location for a further piece of
6 process equipment to access the flow in the manifold.

7
8 Referring now to Figure 3A, there is shown a manifold according to a further alternative
9 embodiment of the invention, generally depicted at 210. The manifold 210 is similar to the
10 manifold 110, and like components are indicated by like reference numerals incremented
11 by 100. The manifold 210 differs from the manifold 110 in that it is a so-called "single
12 header" manifold, which comprises only one main production flowline header 230. As
13 such, the manifold requires only a dual-bore removable module 238, as production fluid is
14 can only be routed to a single production flowline header 230.

15
16 Figure 3B shows an alternative module 252 which could be used in place of the dual-bore
17 removable module 238 shown in Figure 3A. The module 252 differs from the module 238
18 in that it also comprises a multi-phase flow meter 354 to provide the manifold with the
19 additional functionality of performing flow rate measurements for individual phases of the
20 production fluid.

21
22 Referring now to Figure 4A, there is shown a manifold according to a further alternative
23 embodiment of the invention, generally depicted at 310. The manifold 310 is similar to the
24 manifold 110, and like components are indicated by like reference numerals incremented
25 by 200. The manifold 310 differs from the manifold 110 in that it is a so-called "lean single
26 header" manifold, which comprises only one main production flowline header 330.

27
28 A further difference between the manifolds 110 and 310, is that in the manifold 310
29 production fluid flowing from a well and gas flowing from the gas lift flowline header are
30 routed through a shared removable module 338 which is located on a quad-bore access
31 point 337.

32
33 Figure 3B shows an alternative module 352 which could be used in place of the quad-bore
34 removable module 338 shown in Figure 3A. The module 352 differs from the module 338
35 in that it also comprises a multi-phase flow meter 354 to provide the manifold with the

1 additional functionality of performing flow rate measurements for individual phases of the
2 production fluid.

3

4 In accordance with embodiments described above, the invention extends to apparatus in
5 which a removable module contains a sensor package, for example for measuring
6 pressure and/or temperature using transducers in the module (for example, the removable
7 module 14 of Figure 1). However, also as described above, modules with other functions
8 or with multiple functions, including but not limited to the provision of a fluid intervention
9 path, are also within the scope of the invention.

10

11 Figure 5 shows a manifold according to a further alternative embodiment of the invention.
12 The manifold 410 is similar to the manifold 10 of Figure 1 and like components are
13 indicated by like reference numerals incremented by 400. Like the manifold 10, the
14 manifold 410 comprises a main manifold structure 412 and a removable module 414.
15 However, the removable module 414 differs from that of Figure 1 in that it is a multi-
16 purpose removable module.

17

18 Like the module 14 of Figure 1, the module 414 comprises pressure/temperature
19 transducers 422. However, the module 414 also includes an access point 417 for hydraulic
20 intervention operations. In the embodiment shown, the hydraulic intervention flow access
21 point 417 is an ROV hot stab connector. However, it will be appreciated that alternative
22 intervention means may be provided. Therefore, the module 414 can fulfil a fluid
23 measurement functionality (by providing fluid temperature and/or pressure measurements
24 of the fluid) as well as providing an additional flow access functionality for hydraulic
25 intervention operations.

26

27 Another difference between the systems of Figures 1 and 5 is that the flowline 426 is a
28 flexible jumper flowline. To install the removable module between the main manifold
29 structure 412 and the jumper flowline 426, the jumper flowline is disconnected from the
30 manifold structure and parked elsewhere. That is, it is temporarily moved to an alternative
31 location (typically at or near the manifold; however, it could be moved further away from
32 the manifold if required or replaced altogether). The module 414 is then installed on to the
33 manifold 418 with the assistance of an ROV, which makes up the connection between an
34 external connector of the manifold 418 (to which the jumper flowline 426 was previously
35 connected) and a first connector 423 of the module 414. A second connector 424 of the

1 module 414 is a male x female jumper connector which allows the existing jumper flowline
2 426 to be re-installed on the module 414.

3
4 In use, production flow is routed through the jumper flowline 426 upon exiting the manifold
5 410 comprising the main manifold structure 412 and removable module 414, and in to a
6 further manifold 410'. The further manifold 410' is a Pipe Line End Termination (PLET)
7 similar to that for Figure 1. Although the flowline 426 is a flexible flowline, the spacer
8 module 414' may still be provided, whether or not it is required for flowline geometry
9 reasons. However, it will be appreciated that the spacer removable module may be
10 omitted or replaced with a removable module which is able to perform one or more
11 functions.

12
13 For example, Figures 6A to 6C show alternative configurations of the spacer module. In
14 the configurations shown, an additional subsea well can be connected to the flow system
15 via the spacer module. The spacer modules 514a, 514b, 514c are similar to the spacer
16 module 414', and like components are indicated by like reference numerals incremented
17 by 100.

18
19 Figure 6A shows an additional subsea well being connected to the system via a flexible
20 jumper flowline 560a. Figure 6B alternatively shows an additional well being connected via
21 a rigid jumper flowline 560b. The modules can also be connected to composite flowlines or
22 jumper flowlines, or a combination of flexible, rigid and composite jumper flowlines. In both
23 of Figures 6A and 6B, the jumper flowlines are connected to the spacer modules
24 horizontally.

25
26 In the configuration of Figure 6C, the spacer module provides a dedicated vertical
27 connector 561 for the jumper flowline 560c, to receive flow from the additional well.

28
29 Although specific configurations and arrangements are described in the foregoing
30 description, it will be appreciated that the spacer module can be installed between any
31 manifold and flowline within a subsea system, such as between an external opening on the
32 manifold (for example a flowline connector for a jumper flowline) and a jumper flowline. Not
33 only can the spacer modules be installed on a variety of manifolds, they can also be
34 connected at the riser base. Spacer modules can be connected to oil production, gas
35 production, gas injection, gas lift, water injection and utilities and/or service lines, and can

1 be utilised for a multitude of purposes including sensor installation, flowline access, and
2 new well tie-in and connection.

3

4 Although in the foregoing description the invention is described with reference to a well
5 gathering manifold, it will be understood that application of the invention is also relevant to
6 alternative manifold configurations and in particular to distributed manifolds, such as an in-
7 line tee. In such an application, a simple and paired back manifold base structure is
8 provided (i.e. an in-line tee structure with no, or minimal, valving, instrumentation and
9 equipment), with all additional functional elements being provided in one or more manifold
10 removable modules.

11

12 The invention provides a subsea manifold for a subsea production system comprising at
13 least one removable module, and methods of installation and use. The at least one
14 removable is configured to perform a function selected from the group comprising: fluid
15 control, fluid sampling, fluid diversion, fluid recovery, fluid injection, fluid circulation, fluid
16 measurement and/or fluid metering.

17

18 Various modifications to the above-described embodiments may be made within the scope
19 of the invention, and the invention extends to combinations of features other than those
20 expressly claimed herein.

21

1 Claims

- 2
- 3 1. A subsea manifold for a subsea oil and gas production flow system, the subsea
- 4 manifold comprising:
- 5 at first connector configured to be fluidly connected to a subsea well;
- 6 a second connector configured to be fluidly connected to the subsea production flow
- 7 system;
- 8 a flowline header in fluid communication with the second connector; and
- 9 a fluid access point located between the first connector and the flowline header and
- 10 having first and second flow access openings;
- 11 wherein the manifold structure defines a first flow path between the first connector
- 12 and the first flow access opening of the fluid access point and a second flow path
- 13 between the second flow access opening of the fluid access point and the flowline
- 14 header;
- 15 wherein the fluid access point is configured to be connected to a removable module
- 16 comprising a flow path for connecting the first and second fluid access openings
- 17 such that the subsea well and the subsea production flow system are fluidly
- 18 connected by the removable module.
- 19
- 20 2. The subsea manifold according to claim 1, wherein the subsea manifold is a subsea
- 21 Christmas tree, a subsea collection manifold system, a subsea well gathering
- 22 manifold, a subsea distributed manifold system (such as an in-line tee (ILT)), a
- 23 subsea Pipe Line End Manifold (PLEM), a subsea Pipe Line End Termination (PLET)
- 24 and/or a subsea Flow Line End Termination (FLET).
- 25
- 26 3. The subsea manifold according to claim 1 or claim 2, wherein the first connector is
- 27 configured to receive production fluid from a subsea well and/or route a fluid into the
- 28 subsea well.
- 29
- 30 4. The subsea manifold according to any of claims 1 to 3, wherein the first connector is
- 31 configured to deliver gas into the subsea well for gas lift operations.
- 32
- 33 5. The subsea manifold according to any preceding claim, comprising additional
- 34 connectors configured to be fluidly connected to additional subsea wells.
- 35

- 1 6. The subsea manifold according to any preceding claim, wherein the second
2 connector is configured to be connected to an export production flowline of the flow
3 system and/or a gas delivery flowline.
4
- 5 7. The subsea manifold according to any preceding claim, wherein the manifold
6 comprises additional connectors configured to be connected to the subsea
7 production flow system.
8
- 9 8. The subsea manifold according to any preceding claim, wherein the flowline header
10 is a production flowline header
11
- 12 9. The subsea manifold according to any of claims 1 to 7, wherein the flowline header
13 is a gas lift flowline header.
14
- 15 10. The subsea manifold according to any preceding claim, wherein the manifold
16 comprises a plurality of flowline headers.
17
- 18 11. The subsea manifold according to any preceding claim, wherein the fluid access
19 point comprises more than two flow access openings and is a multi-bore fluid access
20 point.
21
- 22 12. The subsea manifold according to any preceding claim, wherein the manifold
23 comprises additional fluid access points.
24
- 25 13. The subsea manifold according to any preceding claim wherein the fluid access point
26 further comprises a third flow access opening, and wherein the manifold further
27 comprises:
28 a third connector configured to be fluidly connected to the subsea production flow
29 system;
30 a second flowline header in communication with the third connector; and
31 a third flow path between the third flow access opening of the fluid access point and
32 the second flowline header;
33 wherein the fluid access point is configured to be connected to a removable module
34 comprising a first flow path for connecting the first and second fluid access openings
35 such that the subsea well and the first flowline header are fluidly connected by the
36 first flow path of the removable module and a second flow path for connecting the

- 1 first and third fluid access openings such that the subsea well and the second
2 flowline header are fluidly connected by the second flow path of the removable
3 module.
4
- 5 14. The subsea manifold according to claim 13, wherein the first and second flow paths
6 of the removable module are fluidly connected.
7
- 8 15. The subsea manifold according to any of claims 1 to 12 wherein the fluid access
9 point further comprises third and fourth flow access opening, and wherein the
10 manifold further comprises:
11 a third connector configured to be fluidly connected to the subsea well;
12 a fourth connector configured to be fluidly connected to the subsea production flow
13 system;
14 a second flowline header in communication with the fourth connector;
15 a third flow path between the third connector and the third flow access opening of the
16 fluid access point; and
17 a fourth flow path between the fourth flow access opening of the fluid access point
18 and the second flowline header.
19 wherein the fluid access point is configured to be connected to a removable module
20 comprising a first flow path for connecting the first and second fluid access openings
21 such that the subsea well and the first flowline header are fluidly connected by the
22 first flow path of the removable module and a second flow path for connecting the
23 third and fourth fluid access openings such that the subsea well and the second
24 flowline header are fluidly connected by the second flow path of the removable
25 module.
26
- 27 16. A removable module for fluidly connecting flow paths within a subsea manifold of a
28 subsea oil and gas production system, the removable module comprising:
29 a body;
30 a first connector; and
31 a second connector;
32 wherein the first and second connectors are configured to be connected to first and
33 second flow access openings of an access point of the subsea manifold,
34 respectively; and

- 1 wherein the body defines a flow path between the first connector and the second
2 connector.
- 3
- 4 17. The removable module according to claim 16, wherein the removable module
5 comprises additional connectors and/or flow paths.
- 6
- 7 18. The removable module according to claim 16 or claim 17, wherein the flow path or
8 paths of the removable module comprise one or more valves.
- 9
- 10 19. The removable module according to any of claims 16 to 18, further comprising
11 equipment and/or instrumentation configured to perform one or more functions
12 selected from the group comprising: fluid control, fluid sampling, fluid diversion, fluid
13 recovery, fluid injection, fluid circulation, fluid access, fluid measurement, flow
14 measurement and/or fluid metering.
- 15
- 16 20. A subsea oil and gas production installation, the installation comprising:
17 at least one subsea well and a subsea production flow system;
18 a subsea manifold according to any of claims 1 to 15; and
19 a removable module;
20 wherein the first connector of the subsea manifold is fluidly connected to the subsea
21 well and the second connector of the subsea manifold is fluidly connected to the
22 subsea production flow system;
23 wherein the removable module comprises a first connector connected to the first flow
24 access opening of the fluid access point of the manifold and a second connector
25 connected to the second opening of the fluid access point of the manifold;
26 wherein the removable module defines a flow path between its first and second
27 connectors such that the subsea well and the subsea production flow system are
28 fluidly connected by the removable module.
- 29
- 30 21. A method of controlling flow between a subsea well and a subsea production
31 system, the method comprising:
32 providing a subsea oil and gas production installation according claim 20, wherein
33 the removable module comprises at least one valve in the flow path between its first
34 and second connectors;

- 1 operating the at least one valve to selectively permit fluid to flow from the subsea
2 well to the subsea production flow system and/or from the subsea production flow
3 system to the subsea well.
4
- 5 22. The method according to claim 21, wherein the flowline header is a production
6 flowline header and the method comprises operating the at least one valve to control
7 flow of production fluid from the subsea well to the production flowline header and
8 subsea production system.
9
- 10 23. The method according to 21, wherein the flowline header is a gas lift flowline header
11 and the method comprises operating the at least one valve to control flow of gas
12 from the gas lift flowline header to the subsea well.
13
- 14 24. The method according to claim 21 or claim 22, wherein the fluid access point further
15 comprises a third flow access opening;
16 wherein the manifold further comprises:
17 a third connector fluidly connected to the subsea production flow system;
18 a second flowline header in communication with the third connector; and
19 a third flow path between the third flow access opening of the fluid access point and
20 the second flowline header;
21 wherein the first and second flowline headers are production flowline headers;
22 wherein the removable module further comprises:
23 a second flow path for connecting the first and third fluid access openings such that
24 the subsea well and the second flowline header are fluidly connected by the second
25 flow path of the removable module, the second flow path comprising at least one
26 valve; and
27 wherein the method comprises operating the at least one valve in the first flow path
28 of the removable module and/or the at least one valve in the second flow path of the
29 removable module to control whether fluid from the subsea well flows into the first
30 and/or the second production flowline headers.
31
- 32 25. The method according to any of claims 21 to 23, wherein the fluid access point
33 further comprises third and fourth flow access openings;
34 wherein the manifold further comprises:

- 1 a third connector fluidly connected to the subsea well;
2 a fourth connector fluidly connected to the subsea production flow system;
3 a second flowline header in communication with the fourth connector
4 a third flow path between the third connector and the third flow access opening; and
5 a fourth flow path between the fourth flow access opening and the second flowline
6 header;
7 wherein the first flowline header is a production flowline header the second flowline
8 header is a gas lift flowline header;
9 wherein the removable module further comprises:
10 a second flow path for connecting the third and fourth fluid access openings such
11 that the subsea well and the second flowline header are fluidly connected by the
12 second flow path of the removable module, the second flow path comprising at least
13 one valve;
14 wherein the method comprises operating the at least one valve in the first flow path
15 of the removable module to selectively permit production fluid to flow from the
16 subsea well to the subsea production flow system via the production flowline header
17 and/or operating the at least one valve in the second flow path of the removable
18 module to selectively control the flow of gas flow from the gas lift flowline header to
19 the subsea well.
20
- 21 26. A method of connecting a new subsea well to a subsea production system, the
22 method comprising:
23 providing a subsea well, a subsea production flow system and a subsea manifold
24 according to any of claims 1 to 15;
25 wherein second connector of the subsea manifold is fluidly connected to the subsea
26 production flow system; and
27 wherein the fluid access point of the subsea manifold is provided with a flow cap;
28 fluidly connecting the subsea well to the first connector of the subsea manifold;
29 removing the flow cap from the fluid access point of the subsea manifold; and
30 connecting a removable module according to any of claims 16 to 19 to the fluid
31 access point of the module such that the subsea well and the subsea production flow
32 system are fluidly connected by the removable module.
33
34