document does not intend to distinguish between components or features that differ in name but not function. Certain features and components herein may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in interest of clarity and conciseness.

In the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to... ." Also, the term "couple" or "couples" is intended to mean either an indirect or direct connection. Thus, if a first device couples to a second device, that connection may be through a direct connection, or through an indirect connection via other devices, components, and connections. In addition, as used herein, the terms "axial" and "axially" generally mean along or parallel to a central axis (e.g., central axis of a body or a port), while the terms "radial" and "radially" generally mean perpendicular to the central axis. For instance, an axial distance refers to a distance measured along or parallel to the central axis, and a radial distance means a distance measured perpendicular to the central axis.

Accordingly, disclosed herein is a downhole equipment suspension system for a well with a production tree. The subsea production tree may be a vertical or horizontal tree. The suspension system may be used for connecting to any type of downhole equipment. For example, the downhole equipment may include a pump for pumping production fluids. Alternative embodiments of the suspension system are disclosed.

FIG. 1 is an illustrative embodiment of a subsea production system 101 including a subsea production tree 110 with a vertical bore. The production system 101 also includes a downhole equipment suspension system. In this embodiment, the subsea production tree shown is a subsea vertical monobore production tree 110 attached above a tubing head spool 202, which is connected with a wellhead ~~208.~~ 216. A tubing hanger 204 with a vertical production bore is landed in the tubing head spool 202 below the tree 110 and supports production tubing 208 extending into the well. As shown in FIGS. 2A–2C, a production casing 220 surrounds the production tubing 208, creating an annular area.

function to disconnect the suspension line 107 from the downhole equipment 210 in the event that the downhole equipment 210 or suspension line 107 is stuck downhole and cannot be retrieved during installation and retrieval.

The downhole equipment suspension system also includes ~~a tree sub~~ an assembly 102 in the production tree 110 that is separate than the tubing hanger 204. In the embodiment shown, the ~~tree sub~~-assembly 102 includes an internal tree cap with flow capabilities that is landed and locked in the upper portion of the production tree 110 to act as one of the environmental barriers for the well. In this embodiment, the tree cap 102 includes an internal bore with an internal profile for a secondary lockdown assembly 104. Also in this embodiment, both the tubing head spool 202 and the production tree 110 include an annulus bypass 222 such that the annular area surrounding the production tubing 208 is in fluid communication with the vertical bore of the production tree 110 above the tubing hanger 204. The internal tree cap includes an annulus flow-by passage 224 in fluid communication with the annulus bypass 222 for establishing fluid communication with the annular area surrounding the production tubing 208 through the internal tree cap. Note that the internal tree cap shown is installable and retrievable by an ROV or by a drill pipe or similar landing string through a riser. The ~~tree sub~~-assembly 102 may also include hydraulically actuated chemical injection valves.

The suspension system also includes a flying lead assembly 103 that includes a debris cap and is ROV deployable. The flying lead assembly 103 is used for connecting an external power source 230 with the downhole equipment 210 in power communication through the suspension line 207. Various electrical connections may be used. As shown, a wet mate electrical connection is located at the bottom of the flying lead assembly 103 that interfaces with the suspension head 106. At the top, the debris cap provides debris protection and includes a high power electrical cable that is connected to a power supply such as a subsea distribution unit. If multiple cables are being connected, orientation may be required when mating the ROV deployable, flying lead connector assembly to a wet mate connection ~~108~~ described below. Other

well and also includes a vertical bore in fluid communication with the bore of the production tubing. Extending laterally from the tree 110a is a lateral production bore 113. The tubing hanger 204a includes a passage extending laterally through the tubing hanger and aligned with the lateral production bore 113 such that production fluids may flow up the production tubing 208, through the tubing hanger 204a, and out the tree through the lateral production bore 113.

The suspension system in FIGS. 2A-2C ~~are~~ is similar to the embodiment shown in FIG. 1 and includes a suspension head 106 suspending downhole equipment 210 in the production tubing with a suspension line. Also included is the flying lead ~~assemby~~ assembly 103. As shown in FIG. 2A, a secondary lockdown assembly 104 and the suspension head 106 are ~~landed in the tree 110a above the tubing hanger 204a but are also~~ landed in the internal tree cap 102 installed in the bore of the tree 110a. As shown in FIG. 2B, the secondary lockdown assembly 104 is landed directly in the production tree 110a and only the suspension head 106 is landed in the internal tree cap 102. As shown in FIG. 2C, both the secondary lockdown assembly 104 and the suspension head 106 are landed directly in the production tree 110a.

Also, the apparatus and method for providing the proper environmental barriers to the well in the top of the production tree 110 or 110a may take multiple suitable forms. For example, an embodiment shown in FIG. 3 can include three different components: a suspension head 302, an intermediate plug 304, and a flying lead 306. The suspension head 302 will be the primary pressure barrier with two testable seal barriers. It may also include an additional gallery seal that divides the two hydraulic lines that may pass thru the cable hanger and down into the coil tubing/cable. The suspension head 302 locks into the tree body and does not require orientation with respect to the tree. It may be installed under protection from the light well intervention (LWI) with a cable hanger running tool. It has a dry mate connection at the bottom and wet mate connection at the top.

The second component is the intermediate plug 304, which serves as the secondary pressure barrier with one testable seal barrier. The intermediate plug 304 may be oriented to the suspension head 302, locked to the internal tree cap, and sealed

CLAIMS

WHAT IS CLAIMED IS:

1. A subsea production system (101) for a well including:

a subsea production tree (110) including a vertical bore;

a tubing hanger (204) including a vertical production bore;

a production tubing (208) ~~extending~~ extended into the well and supported by the tubing hanger (204); and

a downhole equipment suspension system including:

a suspension head (106) supported directly or indirectly by the production tree (110) above and separately from the tubing hanger (204);

downhole equipment (210) inside the production tubing (208) below the tubing hanger (204); and

a suspension line (107) extending through the tubing hanger (204) vertical production bore and the production tree (110) vertical bore and configured to suspend ~~suspending~~ the downhole equipment (210) from the suspension head (106).

2. The system of claim 1, wherein the production tree (110) is a vertical tree.

3. The system of claim 1, wherein the production tree (110) is a horizontal tree.

4. The system of claim 1, wherein the suspension line (107) includes at least one of an electrical conductor, a hydraulic conduit, and a fiber optic cable.

5. The system of claim 1, wherein the downhole equipment (210) includes a pump operated by electrical power, hydraulic power, or both electrical and hydraulic power and the suspension line (107) may be used to convey power to the pump.

6. The system of claim 1, further comprising the suspension head (106) being landed in a ~~tree sub-assembly in the production tree (110)~~an assembly other than the tubing hanger (204), wherein the assembly is supported by the production tree above and separately from the tubing hanger.

7. The system of claim ~~7~~6, wherein the ~~tree sub-~~assembly is ~~an internal~~a tree cap (102).

8. The system of claim 1, further including:

a power source separate from the production tree (110); and

wherein the downhole equipment suspension system includes a flying lead assembly (103) ~~for connecting~~configured to connect the power source (230) with the downhole equipment (210) in power communication through the suspension line (107).

9. The system of claim 1, wherein the production tree (110) includes:

a lateral production bore (113);

a production wing valve block (115) including a wing bore (117) extending from the lateral production bore (113); and

a wing master valve (111) ~~for controlling~~ configured to control fluid flow through the wing bore (117).

10. The system of claim 1, wherein the downhole equipment suspension system includes one or more environmental barriers isolating the well.