

Title: Seawater intake system, jack-up vessel and method

FIELD

5 The invention relates to a seawater intake system for a jack-up vessel. The invention further relates to a jack-up vessel provided with the seawater intake system, and to a method of operating the jack-up vessel.

BACKGROUND

10 Seawater intake systems for jack-up vessels may be beneficial for cooling, firefighting and other purposes on board such vessels. There are two known main approaches to installing such seawater intake systems.

 The first approach involves a submersible pump attached to a rigid pipe. This system can be adjusted to the water depth to overcome leg
15 extension and an air gap. The system, with a rigid pipe, is horizontally supported by guide pipes on the legs of the jack-up system. It is common to install the system after the hull of the jack-up has been raised. The pipes are slidably mounted to the legs of the jack-up system using the guide pipes by installing pipe sections one after the other, lowering each pipe section.
20 The pump is located at the end of the lowest pipe section and is kept under water, taking into account the air gap, the wave height, the water depth and the leg extension. This arrangement provides a rigid system, robust against wave and weather elements, but it is relatively cumbersome to deploy. The sections of the rigid pipe need to be hung in between the guide pipes while
25 the lowest section of the rigid pipe carries the pump. Each pipe section has a fixed length that connects to an onboard piping system, requiring precise alignment of the rigid structure. Dismantling this rigid system for maintenance and/or relocation to retrieve the pump is laborious and poses risks due to lifting operations of large pipe sections.

30 A known alternative involves a submersible pump attached to a flexible hose. This type of pump is lowered below the air gap and water

surface using a hose reel arranged at the hull. The pump hangs underneath the water surface while suspended from the hose reel by the flexible hose. The pump is thus only supported at the reel, wherein the deployed length of hose and the attached pump are consequently free to move with the motion
5 of the waves, potentially allowing the pump to slam against the legs of the jack-up system, depending on the length of the hose and the position of the hose reel. Moreover, the hose is thereby exposed to relatively large forces, resulting in relatively rapid wear.

In view of the above, there is need for an improved seawater intake
10 system for jack-up vessels, in particular to more efficiently operate and install and retrieve pumps while minimizing risks of damage and accidents.

SUMMARY

An object of the invention is to at least partly resolve at least one of
15 the above described disadvantages of known seawater intake systems, in particular while maintaining existing advantages.

An aspect of the invention provides a seawater intake system for a jack-up vessel having legs and a hull. The seawater intake system comprises: a submersible pump having an inlet and an outlet; a seawater
20 channel having a proximal end to be arranged at the hull and a distal end to be connected to the outlet of the submersible pump, wherein at least a proximal section of the seawater channel is formed by a flexible hose, the proximal section being adjacent the proximal end; and an adjustable stiffening arrangement for at least selectively providing to a distal section of
25 the seawater channel increased bending stiffness compared to a bending stiffness of the flexible hose, the distal section extending between the proximal section and the distal end.

The seawater intake system according to this aspect combines advantages of known seawater intake systems that are based on a flexible
30 hose with advantages of known seawater intake systems that are based on a

series of riser pipe sections. The adjustable stiffening arrangement, which can be realized in various ways as explained elsewhere herein, can help to stabilize the distal section of the seawater channel against wave action, while still allowing the use of a flexible hose with associated advantages including reeling. The adjustability of the stiffening arrangement allows to accommodate different levels of the hull with respect to the sea surface and with respect to the legs, in particular without requiring an excessive length of the flexible hose. Meanwhile, the seawater intake system can be put into operation relatively easily compared to known seawater intake systems that are based on a series of riser pipe sections that need to be sequentially assembled and that require precise alignment.

Optionally, the adjustable stiffening arrangement comprises a rigid pipe.

Advantageously, a rigid pipe can be relatively stiff compared to a flexible hose and can thus provide at least part of the increased bending stiffness, in particular while still allowing advantageous use of the flexible hose.

Optionally, an inflow end of the rigid pipe is connectable, in particular rigidly connectable, to the outlet of the submersible pump.

In this way, the rigid pipe can provide stiffness adjacent the outlet of the pump, in particular so as to continue a rigidity of the pump itself beyond its outlet. Seawater flowing out of the pump can thus flow into the rigid pipe.

Optionally, an inflow end of the flexible hose is connectable to an outflow end of the rigid pipe.

In this way, seawater flowing out of the rigid pipe can flow into the flexible hose. The flexible hose may thus be liquidly connected to the outlet of the pump via the rigid pipe.

Optionally, the rigid pipe at least partly forms the distal section of the seawater channel.

Thus, the rigid pipe may not only provide increased bending stiffness to the distal section, but may at the same time itself form part or all of the distal section of the seawater channel, thereby having multiple functions as part of the system. Alternatively, for example, the rigid pipe
5 could surround a section of the flexible hose adjacent the pump. In either case, the stiffening arrangement comprising the rigid pipe may be adjustable e.g. by allowing the rigid pipe to be assembled to and disassembled from the pump and/or the flexible hose.

Optionally, the rigid pipe has a pipe length that is larger than a
10 largest dimension of the submersible pump.

In this way, increased bending stiffness can be provided along a relatively long length, in particular also compared to a size of the pump.

Optionally, the seawater intake system comprises one or more guide rails fixed or fixable to one of the legs so as to extend along said leg to
15 guide the submersible pump and/or the seawater channel along said leg.

Such guide rails are known as such from seawater intake systems that are based on a series of riser pipe sections and that do not comprise a flexible hose. Advantageously, such guide rails can be used to advantage in the present context, thus allowing reuse of those guide rails.

Optionally, the one or more guide rails form part of the adjustable stiffening arrangement, wherein the adjustable stiffening arrangement further comprises a series of carriages attached or attachable to the distal section of the seawater channel, in particular to the flexible hose and/or to the optional rigid pipe, and releasably engageable with the one or more
20 guide rails.
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Advantageously, the combination of the attached carriages can provide increased stiffness when engaged with the one or more guide rails, which are by definition rigid and are moreover fixed to the leg during use. Meanwhile, to adjust the stiffening arrangement, the carriages can be
30 released from the one or more guide rails.

Optionally, the adjustable stiffening arrangement is configured to allow the carriages to be at least selectively constrained by the one or more guide rails when engaged.

Such constraining can advantageously cause the rigidity of the
5 guide rails to be at least partly imposed on the part of the seawater channel to which the carriages are attached.

Optionally, the constraining limits the freedom of movement of the carriages to translations along the guide rails.

In this way, essentially all of the rigidity of the guide rails can be
10 imposed on the part of the seawater channel to which the carriages are attached, while still allowing the vertical level of the pump to be adjusted with respect to the leg.

Optionally, the carriages are adjustable between an engaging configuration and a disengaging configuration. In the engaging
15 configuration, the carriage can be engaged with the one or more guide rails so as to be constrained by the one or more guide rails. In the disengaging configuration, the carriage can be disengaged from the one or more guide rails so as to be releasable from the guide rails.

In this way, selective engagement or disengagement of the
20 carriages can be realized by adjustment of the respective carriage itself, in particular without requiring disassembly or other adjustment of the guide rails.

Optionally, the carriages comprise a respective base attached or attachable to the distal section and one or more respective wings hinged
25 connected to the base so as to be rotatably adjustable with respect to the base between an engaging position and a disengaging position. In the engaging position, the one or more wings can be engaged with the one or more guide rails and the carriage is in the engaging configuration. In the disengaging position, the one or more wings can be disengaged from the one
30 or more guide rails and the carriage is in the disengaging configuration.

Such an arrangement can provide the adjustability of the carriage between the engaging configuration and the disengaging configuration in a relatively robust and effective manner. In particular, a size of the carriage in a plane transverse to the main direction of the seawater channel may
5 thus be reduced in the disengaging configuration compared to the engaging configuration. The hinging axis or axes for the one or more wings may extend in such a transverse plane, in particular substantially tangential with respect to a circumference of seawater channel. The rotational adjustment may for example be effected by an operator.

10 Optionally, the carriage has a locking arrangement for releasably locking the one or more wings in the engaging position so as to selectively secure the engagement between the carriage and the one or more guide rails.

 In this way, it can be promoted that the engagement is maintained,
15 in particular also when the carriages are impacted by wave action or other external factors. Since the locking is releasable, an operator can still realize disengagement.

 Optionally, the carriage has one or more stops configured to prevent the one or more wings from rotating beyond the engaging position
20 from the disengaging position.

 Such stops can make it easier for an operator to adjust the carriages correctly. Moreover, such stops can provide a fail safe function with respect to the optional locking arrangement, e.g. by preventing the wings from falling away from the engaging position. Thus, the stops may be
25 configured to prevent the one or more wings from rotating downward, wherein preferably in the disengaging position, compared to the engaging position, the wings are rotated upward with respect to the base.

 Optionally, the number of guide rails of the one or more guide rails is at least two, wherein the carriage is engageable with the guide rails so as

to be constrained by the guide rails when the carriage is in between the guide rails.

Such an arrangement can provide the preferred constraining in a relatively simple yet effective manner.

5 Optionally, at least some of the carriages are attached or attachable to the flexible hose.

In this way, the stiffening arrangement can provide increased bending stiffness to a part of the distal section that is formed by the flexible hose, e.g. as alternative or addition to a part of the distal section that may
10 be formed by a rigid pipe as described elsewhere herein. Thus, optionally, the flexible hose, in particular a distal section thereof, at least partly forms the distal section of the seawater channel, preferably wherein at least some of the carriages are attached or attachable to the distal section of the flexible hose. Meanwhile, a proximal section of the flexible hose may form
15 the proximal section of the seawater channel.

Optionally, the seawater intake system further comprises a hose reel to be arranged at the hull and configured for at least the proximal section of the seawater channel to be reeled thereon.

Such a hose reel is known as such from seawater intake systems in
20 which a flexible hose is directly connected to the pump without any adjustable stiffening arrangement. Advantageously, such a hose reel can be used with essentially corresponding advantages in the present context. In particular, the flexible hose may be reeled on the hose reel to raise the pump with respect to the hull or may be reeled off the hose reel to lower the pump
25 with respect to the hull. The weight of the pump and the seawater channel may be partly or fully carried by the hose reel. The hose reel may be motorized to power and control the reeling.

Optionally, the distal section of the seawater channel has a channel length of at least 4 meters, preferably at least 6 meters, more preferably at
30 least 8 meters, measured from the outlet of the submersible pump.

In this way, a relatively large distal section of the seawater channel may be provided with increased stiffness, allowing the system to be operated effectively and safely even during relatively large waves. As explained elsewhere herein, the distal section of the seawater channel may
5 or may not be partly or completely formed by a rigid pipe, and may or may not be partly or completely formed by a distal section of the flexible hose. In view thereof, a length of the optional rigid pipe may be different from, or the same as, the channel length of the distal section of the seawater channel. Meanwhile, the distal section of the flexible hose may provide part, all or
10 none of the channel length of the distal section of the seawater channel.

Optionally, the distal section of the seawater channel has a channel length of at most 30 meters, preferably at most 25 meters, more preferably at most 20 meters.

In this way, the system can be relatively easy to operate and be
15 relatively cost effective, in particular allowing a relatively large part of the seawater channel to be formed by the flexible hose and providing increased stiffness only where most needed, i.e. where the seawater channel may be impacted by wave action.

Optionally, the proximal section of the seawater channel has a
20 channel length of at least 20 meters, preferably at least 30 meters, more preferably at least 40 meters.

The pump may thus be lowered relatively far below the hull, in particular without requiring an excessive length of the distal section. Thereby, the system can be suitable for relatively high levels of the hull
25 above the sea while still being relatively effective and easy to operate. As explained elsewhere herein, while the flexible hose forms at least the proximal section of the seawater channel, the flexible hose may or may not additionally at least partly form the distal section of the seawater channel. In view thereof, a length of the flexible hose may be different from, or the
30 same as, the channel length of the proximal section of the seawater channel.

Optionally, the pump extends from the outlet of the pump along a pump length of at most 10 m, preferably at most 8 m, more preferably at most 6 m, for example 5 m or less.

In this way, the pump can be relatively compact to facilitate
5 maintenance and transport thereof. Meanwhile, the seawater channel can be relatively long to allow pumped seawater to reach the level of the hull.

A further aspect provides a jack-up vessel provided with a seawater intake system as described herein, wherein the proximal end of the seawater channel is arranged at the hull.

10 Such a jack-up vessel provides advantages corresponding to those described herein for the seawater intake system.

Optionally, the proximal end of the seawater channel is liquidly connected to a seawater tank of the jack-up vessel so as to allow seawater to flow from the seawater channel to the seawater tank.

15 Such a seawater tank advantageously allows a volume of pumped seawater to be stored, in particular buffered, for later use. In turn, this may allow the intake flow rate of the seawater intake system to be smaller than the maximum expected total consumption flow rate for seawater at the jack-up vessel.

20 A further aspect provides a method of operating a jack-up vessel as described herein. The method comprises, at an offshore location, performing jacking to lower the legs to the sea floor and raise the hull to a level above the sea surface. The method comprises, during the jacking and/or while the hull is raised to the level above the sea surface, lowering the submersible
25 pump with respect to the hull so as to become submersed in the sea, while the distal end of the seawater channel is connected to the outlet of the submersible pump. The method comprises, before and/or during the lowering of the submersible pump, adjusting the adjustable stiffening arrangement to provide the increased bending stiffness to the distal section

of the seawater channel while the distal section is below the level of the hull.

Such a method provides advantages corresponding to those described herein for the seawater intake system.

5 Optionally, the adjusting of the adjustable stiffening arrangement comprises assembling the rigid pipe as part of the adjustable stiffening arrangement and preferably as part of the distal section of the seawater channel.

 Optionally, the adjusting of the adjustable stiffening arrangement
10 comprises causing the carriages to engage with the one or more guide rails, preferably so as to be constrained by the one or more guide rails.

 Optionally, the causing of the carriages to engage with the one or more guide rails comprises causing the one or more wings of the respective carriage to rotate from the disengaging position to the engaging position so
15 as to engage with the one or more guide rails, and preferably securing the one or more wings in the engaging position.

 Optionally, the hose reel is operated to reel out at least part of the proximal section to allow the submersible pump to be lowered, in particular under influence of gravity.

20 Advantages of the above mentioned options for the method shall be readily appreciated in view of explanations provided elsewhere herein, in particular with respect to corresponding options for the seawater intake system and the jack-up vessel.

 Optionally, after the jacking and the lowering of the submersible
25 pump, the distal section provided with the increased bending stiffness extends to above the sea surface. In this way, the increased bending stiffness can be a relatively effective means against disturbances from wave action.

 Optionally, the method further comprises at least partly reversing
30 the adjusting of the adjustable stiffening arrangement to reduce the

stiffness of the distal section to allow the submersible pump and the legs to be raised with respect to the hull. In this way, the submersible pump can be raised to a relatively high level, e.g. to accommodate a sailing configuration of the jack-up vessel, in particular without requiring an excessive length of the flexible hose or any other part of the seawater channel.

5 CN219280659U discloses a seawater intake system comprising a flexible hose directly connected to a submersible pump. Here, a carriage engageable with guide rails is provided only at the submersible pump, so that during use a distal section of the flexible hose is disadvantageously impacted and deformed due to wave action.

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DETAILED DESCRIPTION

In the following, the invention will be explained further using examples of embodiments and drawings. The drawings are schematic and merely show examples. In the drawings, corresponding elements are indicated by corresponding reference signs. In the drawings:

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Fig. 1 shows a partial side view of a jack-up vessel provided with a seawater intake system, wherein the hull is supported on the legs to be above the sea surface and the submersible pump is submersed below the sea surface;

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Fig. 2 shows an enlarged view of detail II of Fig. 1;

Fig. 3 shows a partial side view of the jack-up vessel, wherein compared to Fig. 1 the hull has been lowered with respect to the leg;

Figs. 4A – 4D each show a perspective view of a carriage of a stiffening arrangement of the seawater intake system, wherein one wing of the carriage is in an engaging position and a further wing of the carriage is in a disengaging position;

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Figs. 5A and 5B show a top view and a side view, respectively, of the carriage engaged with guide rails; and

Figs. 6A and 6B show a top view and a side view, respectively, of the carriage disengaged from the guide rails.

The figures show an example of a seawater intake system 1 for a jack-up vessel 2 having legs 3 and a hull 4. The seawater intake system 1 comprises a submersible pump 5 having an inlet 6 and an outlet 7. The seawater intake system 1 comprises a seawater channel 8 having a proximal end 9 to be arranged at the hull 4 and a distal end 10 to be connected to the outlet 7 of the submersible pump 5. At least a proximal section 11 of the seawater channel 8 is formed by a flexible hose 12, the proximal section 11 being adjacent the proximal end 9. The seawater intake system 1 comprises an adjustable stiffening arrangement 13 for at least selectively providing to a distal section 14 of the seawater channel 8 increased bending stiffness compared to a bending stiffness of the flexible hose 12, the distal section 14 extending between the proximal section 11 and the distal end 10.

The figures also show an example of a jack-up vessel 2 provided with the seawater intake system 1, wherein the proximal end 9 of the seawater channel 8 is arranged at the hull 4.

In Fig. 1, it can be seen that the hull 4 is here at a raised level with respect to the leg 3, as may be typical when the hull 4 is supported on the sea floor via the legs 3. As indicated in Fig. 1, the hull 4 can thus be at a vertical distance, also known as an air gap 31, from the sea surface SS. Wave action may occur at the sea surface SS, represented here by an expected wave profile WP having a maximum WP_{max}, i.e. the level of the top of the largest expected wave, and a minimum WP_{min}, i.e. the level of the lowest expected trough between waves.

As best seen in the enlarged view of Fig. 2, the submersible pump 5, in particular its inlet 6, is here positioned below the minimum WP_{min} of the wave profile WP, so that seawater can continue to be taken in via the pump 5 also when such a minimum of the wave profile WP occurs at the leg 3. The distal section 14 of the seawater channel 8, i.e. the section to which

increased bending stiffness is provided by the adjustable stiffening arrangement 13, extends here upward from the pump 5 to a level above the sea surface SS, so that disturbance of the seawater channel 8 from wave action can be reduced to a suitably low level. Depending on the specific
5 conditions, it may not be necessary for the distal section 14 to extend up to or beyond the maximum WPmax of the wave profile WP, because disturbances at such high levels may be relatively small and/or rare.

In the shown example, the distal section 14 of the seawater channel 8 has a channel length of at least 4 meters, preferably at least 6
10 meters, more preferably at least 8 meters, measured from the outlet 7 of the submersible pump 5. In the shown example, the distal section 14 of the seawater channel 8 has a channel length of at most 30 meters, preferably at most 25 meters, more preferably at most 20 meters. The proximal section 11 of the seawater channel 8 may have a channel length of at least 20 meters,
15 preferably at least 30 meters, more preferably at least 40 meters. In the shown example, the proximal end 9 of the seawater channel 8 is liquidly connected to a seawater tank 26 of the jack-up vessel 2 so as to allow seawater to flow from the seawater channel 8 to the seawater tank 26.

A method of operating the jack-up vessel 2 comprises: at an
20 offshore location, performing jacking to lower the legs 3 to the sea floor and raise the hull 4 to a level above the sea surface SS; during the jacking and/or while the hull 4 is raised to the level above the sea surface SS, lowering the submersible pump 5 with respect to the hull 4 so as to become submersed in the sea 27, while the distal end 10 of the seawater channel 8 is connected to
25 the outlet 7 of the submersible pump 5; and before and/or during the lowering of the submersible pump 5, adjusting the adjustable stiffening arrangement 13 to provide the increased bending stiffness to the distal section 14 of the seawater channel 8 while the distal section 14 is below the level of the hull 4.

With reference to Figs. 1 and 2 as illustration, after the jacking and the lowering of the submersible pump 5, the distal section 14 provided with the increased bending stiffness may extend to above the sea surface SS.

With reference to Fig. 3, the method of operating the jack-up vessel
5 may further comprise at least partly reversing the adjusting of the adjustable stiffening arrangement 13 to reduce the stiffness of the distal section 14 to allow the submersible pump 5 and the legs 3 to be raised with respect to the hull 4.

In a sailing configuration of the jack-up vessel 2, e.g. as shown in
10 Fig. 3, the legs 3 are typically raised with respect to the hull 4, for example such that feet 28 of the legs 3 are at a lower side of the hull 4. In this configuration, the pump 5 is also raised, for example to a level at or above the hull 4. In this configuration, the adjustable stiffening arrangement 13 may be partly or fully removed from the seawater channel 8, although in
15 some cases the arrangement 13 or one or more parts thereof can also remain at the seawater channel 8, e.g. for easy and quick redeployment of the system 1. In the example shown in Fig. 3, compared to Figs. 1 and 2, about five carriages 20 of the stiffening arrangement 13 have been temporarily removed, while other parts including guide rails 19 and a rigid pipe 15
20 remain. In this way, among possible other ways, the stiffening arrangement 13 can be adjusted, in particular so as to adjust the provided stiffness between a lower stiffness when the distal section 14 and the pump 5 are at the level of the hull 4 and a higher stiffness when the pump 5 is submersed below the sea surface SS. As explained further elsewhere herein, other
25 possible ways of adjusting the stiffening arrangement 13 include: adjusting carriages 20 between an engaging configuration and CE and a disengaging configuration CD; and assembling or disassembling a rigid pipe 15. In some variants, more, fewer or no carriages 20 may need to be removed, e.g. depending on available space in the arrangement, when the leg 3 is fully
30 retracted as in Fig. 3.

The adjustment of the stiffening arrangement 13 may be effected by one or more operators, optionally using one or more tools such as one or more hand tools and/or a crane and/or a winch. Such one or more operators may for example be stationed on a platform associated with a jacking
5 mechanism 29 for the respective leg 3. The jacking mechanism 29 is normally fixed to the hull 4, surrounding the leg 3. In Fig. 3, merely for clarity of the drawing, a part of the leg 3 at the level of the jacking mechanism 29 is not shown.

In the shown example, the adjustable stiffening arrangement 13
10 comprises a rigid pipe 15. It shall be appreciated that such a rigid pipe 15 may be formed as a single integral pipe or alternatively may be assembled from multiple pipe sections. Such a pipe or pipe section may be referred to as a riser pipe or pipe riser on account of its upright orientation during use, in particular in combination with the upward direction of flow through the
15 pipe.

In the shown example, an inflow end 16 of the rigid pipe 15 is connected to the outlet 7 of the submersible pump 5. In the shown example, an inflow end 17 of the flexible hose 12 is connected to an outflow end 18 of the rigid pipe 15. In the shown example, the rigid pipe 15 has a pipe length
20 that is larger than a largest dimension of the submersible pump 5. Meanwhile, with reference to Fig. 3, to allow the rigid pipe 30 to remain connected to the hose 12 if desired, the pipe length of the rigid pipe 15 is preferably smaller than a distance between a foot 28 of the leg 3 and a hose guide 30 when the leg 3 is fully retracted, i.e. when the leg 3 is at its highest
25 level with respect to the hull 4.

In the shown example, the rigid pipe 15 partly forms the distal section 14 of the seawater channel 8, wherein the distal section 14 is further partly formed by the flexible hose 12, as best seen in Fig. 2. Alternatively, the rigid pipe could form all of the distal section. Further alternatively, the
30 rigid pipe could be omitted, wherein the distal section is then for example

formed by the flexible hose only, in particular in case the flexible hose is provided with a series of guide rails engaging carriages as explained elsewhere herein.

The adjusting of the adjustable stiffening arrangement 13 may
5 comprise assembling the rigid pipe 15 as part of the adjustable stiffening arrangement 13 and preferably as part of the distal section 14 of the seawater channel 8.

In the shown example, the seawater intake system 1 comprises one or more, here two, guide rails 19 fixed or fixable to one of the legs 3 so as to
10 extend along said leg 3 to guide the submersible pump 5 and/or the seawater channel 8 along said leg 3. Such guide rails 19 may be formed in various ways. In a preferred embodiment, and in the shown example, the guide rails 19 are formed as respective pipes. These pipes 19 may be used as jetting pipes for feeding jetting nozzles at the feet 28, for example.

15 Alternatively or additionally, a power line may run through such a pipe 19.

In the shown example, the one or more guide rails 19 form part of the adjustable stiffening arrangement 13, wherein the adjustable stiffening arrangement 13 further comprises a series of carriages 20 attached or attachable to the distal section 14 of the seawater channel 8 and releasably
20 engageable with the one or more guide rails 19. In the shown example, at least some of the carriages 20 are attached or attachable to the flexible hose 12, in particular to a distal section thereof which in this case partly forms the distal section 14 of the seawater channel 8. Six of such carriages 20 can be seen in Fig. 2, attached to the flexible hose 12 at regular intervals along
25 the hose 12, starting from the distal inflow end 17 of the hose 12. Here the upper most carriage 20 effectively defines the upper limit of the distal section 14. A further carriage 20 is in this example provided at the lower end of the pump 5 so as to guide the pump 5 with respect to the guide rails 19 and thereby further stiffen the seawater channel 8. It shall be

appreciated that still further carriages may be provided along the seawater channel 8 and/or the pump 5.

A possible design for such a carriage 20 is shown in more detail in Figs. 4A to 6B, as will be explained further herein. As shown for example in
5 Fig. 3, one or more such carriages may additionally be attached to the rigid pipe 15 and/or to the submersible pump 5 so as to allow also those parts to be guided and preferably constrained by the guide rails 19. The specific design of the carriage may be adjusted to accommodate the part to which it is attached. For example, in case an outer diameter of the pump 5 is larger
10 than an outer diameter of the pipe 15 or the hose 12, an inner diameter of a carriage for the pump 5 may be correspondingly larger than an inner diameter of a carriage for the pipe 15 or hose 12.

In the shown example, with particular reference to Figs. 5A-B, the adjustable stiffening arrangement 13 is configured to allow the carriages 20
15 to be at least selectively constrained by the one or more guide rails 19 when engaged. In the shown example, the constraining limits the freedom of movement of the carriages 20 to translations along the guide rails 19. In the shown example, the number of guide rails 19 of the one or more guide rails 19 is at least two, wherein the carriage 20 is engageable with the guide rails
20 19 so as to be constrained by the guide rails 19 when the carriage 20 is in between the guide rails 19. End stops 32 may be provided at the lower end of the guide rails 19 to impose a lowest possible position of the pump 5 with respect to the guide rails 19.

The adjusting of the adjustable stiffening arrangement 13 may
25 comprise causing the carriages 20 to engage with the one or more guide rails 19, preferably so as to be constrained by the one or more guide rails 19.

In the shown example, the carriages 20 are adjustable between an engaging configuration CE and a disengaging configuration CD. In the engaging configuration CE, e.g. as shown in Figs. 5A-B, the carriage 20 can
30 be engaged with the one or more guide rails 19 so as to be constrained by

the one or more guide rails 19. In the disengaging configuration CD, e.g. as shown in Figs. 6A-B, the carriage 20 can be disengaged from the one or more guide rails 19 so as to be releasable from the guide rails 19.

In the shown example, the carriages 20 comprise a respective base
5 21 attached or attachable to the distal section 14 and one or more respective wings 22 hingedly connected to the base 21 so as to be rotatably adjustable with respect to the base 21 between an engaging position PE and a disengaging position PD. In the engaging position PE, the one or more wings 22 can be engaged with the one or more guide rails 19 and the carriage 20 is
10 in the engaging configuration CE. In the disengaging position PD, the one or more wings 22 can be disengaged from the one or more guide rails 19 and the carriage 20 is in the disengaging configuration CD.

In Figs. 4A to 5B, merely for illustrative purposes, the carriage 20 is shown with one of the wings 22 in the engaging position PE and another
15 one of the wings 22 in the disengaging position PD. It shall be appreciated that in practice, for most of the time, the wings 22 of a same carriage 20 would typically be in a same one of said positions. However, it may also be appreciated from Figs. 4A to 6B that in a possible alternative design, the carriage could have only a single rotatable wing, whereas the other wing
20 may essentially be replaced by a correspondingly formed integral part of the base. In that case, the configuration shown in Figs. 4A-D may essentially correspond to a disengaging configuration.

In Figs. 5A-B, it can be seen that in this example, in the engaging configuration CE, the carriage 20 is constrained by the guide rails 19 to
25 allow only translation of the carriage 20 along the guide rails 19, i.e. up and down. Other degrees of freedom are essentially taken away by the engagement between the wings 22 and the guide rails 19, especially in case multiple carriages 20 are arranged relatively closely together along the hose 12 or other part of the distal section 14. In view thereof, and more generally
30 to provide a relatively effective increase in bending stiffness, the carriages

20 may be arranged along the distal section 14 with an interspacing between the carriages 20 that is smaller than ten times the local diameter of the seawater channel 8, preferably smaller than five times the local diameter, for example about three or four times the local diameter.

- 5 Meanwhile, to promote efficient production and operation of the arrangement, said interspacing is preferably larger than said local diameter.

In the shown example, the carriage 20 has a locking arrangement 23, in particular comprising a locking pin and corresponding locking pin
10 holes, for releasably locking the one or more wings 22 in the engaging position PE so as to selectively secure the engagement between the carriage 20 and the one or more guide rails 19. The locking arrangement 23 may additionally be configured to allow the one or more wings 22 to be releasably locked in the disengaging position PD. The locking arrangement 23 may be
15 operated by an operator, e.g. using a hammer to engage or disengage the locking pin, around the same time as adjusting the carriage 20 between the engaging configuration CE and the disengaging configuration CD.

The causing of the carriages 20 to engage with the one or more guide rails 19 may comprise causing the one or more wings 22 of the
20 respective carriage 20 to rotate from the disengaging position PD to the engaging position PE so as to engage with the one or more guide rails 19, and preferably securing the one or more wings 22 in the engaging position PE.

In the shown example, the carriage 20 has one or more stops 24
25 configured to prevent the one or more wings 22 from rotating beyond the engaging position PE from the disengaging position PD.

In the shown example, the seawater intake system 1 further comprises a hose reel 25 to be arranged at the hull 4 and configured for at least the proximal section 9 of the seawater channel 8 to be reeled thereon.
30 The hose reel 25 may be operated to reel out at least part of the proximal

section 11 to allow the submersible pump 5 to be lowered, in particular under influence of gravity. To raise the submersible pump 5, the hose reel 25 may be operated to reel in at least part of the proximal section 11. Thus, the level of the pump 5 with respect to the hull 4 may be adjustable by
5 operating the hose reel 25. Such adjustment may be contemporaneous with a jacking operation in which a level of the respective leg 3 with respect to the hull 4 is adjusted, for example such that the level of the pump 5 with respect to the leg 3 is substantially constant. Alternatively or additionally, the level of the pump 5 with respect to the leg 3 may be adjusted using the
10 hose reel 25, e.g. depending on the distance between the foot 28 and the sea surface SS.

A hose guide 30 may be provided to guide the hose 12 along a curved path that smoothly interconnects a straight upright path defined by the guide rails 19 and a straight path extending between the hose reel 25
15 and the hose guide 30. Such a hose guide may be or comprise a chute and/or one or more passive or active rollers.

A power cable (not shown) for the pump 5 may be coupled to and/or integrated with the seawater channel 8 and/or parts thereof. Alternatively, such a power cable may be guided between the hull 4 and the pump 5
20 substantially separately from the seawater channel 8. A winch cable (not shown) may be connected to the pump 5 and/or the rigid pipe 15 and/or the inflow end 17 of the hose 12 to support the reeling in of the hose 12 and/or to allow the pump 5 and/or pipe 15 to be lifted away from the guide rails 19, e.g. for maintenance. Also such a winch cable may be coupled to and/or
25 integrated with the seawater channel 8 and/or parts thereof.

To facilitate maintenance, the pump 5 and/or the pipe 15 may be decoupled from the guide rails 19. Starting e.g. from a situation as shown in Fig. 3, any engaged carriages 20 may be disengaged and the pump 5 and/or pipe 15 may be lifted away from the leg 3 and subsequently e.g. lowered
30 onto a deck of the hull 4 using a crane or the like. At this time, if it is

desired to fully separate the pump 5 from the hose 12, the hose 12 may be reeled out and laid on the deck to allow a power cable and/or winch cable for the pump 5, that may normally be arranged on or in the hose 12 as explained elsewhere herein, to be separated from the hose 12, e.g. while
5 remaining connected to the pump 5. After maintenance has been completed, the process can essentially be reversed, to return to the situation e.g. as shown in Fig. 3. Conveniently, the pump 5 and optional pipe 15 can then continue to be engaged with the guide rails 19, and the hose 12 can continue to be fluidly connected to the pump 5 and/or pipe 15, until a subsequent
10 round of maintenance may be needed. In this way, the pump 5 is normally easily and quickly deployed, in particular using reeling of the hose 12, without necessarily requiring a crane.

To further facilitate deployment, use, and maintenance, a hose reel controller may be configured to control the reeling of the hose reel 25 for
15 lowering and/or raising of the pump 5 with respect to the hull 4, in particular such that the lowering and/or raising is at least partly automated. Preferably, the hose reel controller is configured to receive data representative of a position of the associated leg 3 with respect to the hull 4, e.g. from a jacking control system associated with the jacking mechanism
20 29. In this way, for example, the lowering and/or raising of the pump 5 may be controlled to at least partly match, e.g. follow or anticipate, a lowering and/or raising of the associated leg 3. Thereby, it may be facilitated that the inlet 6 of the pump 5 is submersed when the pump 5 is active so as to prevent cavitation and/or loss of priming of the pump 5, e.g. by promoting
25 that the inlet 6 is below the minimum WP_{min} of the wave profile WP as explained elsewhere herein. Thereto, information about said minimum WP_{min}, e.g. with respect to the sea floor on which the foot 28 of the leg 3 may be supported, may be made available as a reference to the hose reel controller. It shall be appreciated that additionally or alternatively one or

more other levels than said minimum WPmin may be used as a reference, e.g. including the level of the sea surface SS.

Also, potential accidents due to unintentional mechanical interactions between the intake system 1 and the leg 3 may be prevented by such automation of the hose reel 25. Alternatively or additionally, to help prevent such accidents, a controller may be configured to generate a warning signal based on a combination of the data representative of the position of the leg 3 and data representative of a state of the intake system 1, in particular the hose reel 25.

Although the invention has been explained herein using examples of embodiments and drawings, these do not limit the scope of the invention as defined by the claims. Within said scope, many variations, combinations and extensions are possible, as shall be appreciated by the skilled person having the benefit of the present disclosure. All such variants are included in the scope of the invention as defined by the claims.

LIST OF REFERENCE SIGNS

	1.	Seawater intake system
	2.	Jack-up vessel
	3.	Leg
5	4.	Hull
	5.	Submersible pump
	6.	Inlet of submersible pump
	7.	Outlet of submersible pump
	8.	Seawater channel
10	9.	Proximal end of seawater channel
	10.	Distal end of seawater channel
	11.	Proximal section of seawater channel
	12.	Flexible hose
	13.	Adjustable stiffening arrangement
15	14.	Distal section of seawater channel
	15.	Rigid pipe
	16.	Inflow end of rigid pipe
	17.	Inflow end of flexible hose
	18.	Outflow end of rigid pipe
20	19.	Guide rail
	20.	Carriage
	21.	Base of carriage
	22.	Wing of carriage
	23.	Locking arrangement of carriage
25	24.	Stop of carriage
	25.	Hose reel
	26.	Seawater tank
	27.	Sea
	28.	Foot
30	29.	Jacking mechanism

	30.	Hose guide
	31.	Air gap
	32.	End stop of guide rails
	CD.	Disengaging configuration of carriage
5	CE.	Engaging configuration of carriage
	PD.	Disengaging position of wing
	PE.	Engaging position of wing
	SS.	Sea surface
	WP.	Wave profile
10	WPmax.	Maximum of wave profile
	WPmin.	Minimum of wave profile

Claims

1. Seawater intake system for a jack-up vessel having legs and a hull, comprising:
 - a submersible pump having an inlet and an outlet;
 - a seawater channel having a proximal end to be arranged at the hull and a distal end to be connected to the outlet of the submersible pump, wherein at least a proximal section of the seawater channel is formed by a flexible hose, the proximal section being adjacent the proximal end; and
 - an adjustable stiffening arrangement for at least selectively providing to a distal section of the seawater channel increased bending stiffness compared to a bending stiffness of the flexible hose, the distal section extending between the proximal section and the distal end.
2. Seawater intake system according to claim 1, wherein the adjustable stiffening arrangement comprises a rigid pipe.
3. Seawater intake system according to claim 2, wherein an inflow end of the rigid pipe is connectable to the outlet of the submersible pump.
4. Seawater intake system according to claim 2 or 3, wherein an inflow end of the flexible hose is connectable to an outflow end of the rigid pipe.
5. Seawater intake system according to any of claims 2 – 4, wherein the rigid pipe at least partly forms the distal section of the seawater channel.

6. Seawater intake system according to any of claims 2 – 5, wherein the rigid pipe has a pipe length that is larger than a largest dimension of the submersible pump.
- 5 7. Seawater intake system according to any of the preceding claims, comprising one or more guide rails fixed or fixable to one of the legs so as to extend along said leg to guide the submersible pump and/or the seawater channel along said leg.
- 10 8. Seawater intake system according to claim 7, wherein the one or more guide rails form part of the adjustable stiffening arrangement, wherein the adjustable stiffening arrangement further comprises a series of carriages attached or attachable to the distal section of the seawater channel and releasably engageable with the one or more guide rails.
- 15 9. Seawater intake system according to claim 8, wherein the adjustable stiffening arrangement is configured to allow the carriages to be at least selectively constrained by the one or more guide rails when engaged.
- 20 10. Seawater intake system according to claim 9, wherein the constraining limits the freedom of movement of the carriages to translations along the guide rails.
- 25 11. Seawater intake system according to claim 9 or 10, wherein the carriages are adjustable between an engaging configuration and a disengaging configuration,
wherein, in the engaging configuration, the carriage can be engaged with the one or more guide rails so as to be constrained by the one or more guide rails,

wherein, in the disengaging configuration, the carriage can be disengaged from the one or more guide rails so as to be releasable from the guide rails.

5 12. Seawater intake system according to claim 11, wherein the carriages comprise a respective base attached or attachable to the distal section and one or more respective wings hingedly connected to the base so as to be rotatably adjustable with respect to the base between an engaging position and a disengaging position,

10 wherein, in the engaging position, the one or more wings can be engaged with the one or more guide rails and the carriage is in the engaging configuration,

wherein, in the disengaging position, the one or more wings can be disengaged from the one or more guide rails and the carriage is in the
15 disengaging configuration.

13. Seawater intake system according to claim 12, wherein the carriage has a locking arrangement for releasably locking the one or more wings in the engaging position so as to selectively secure the engagement
20 between the carriage and the one or more guide rails.

14. Seawater intake system according to claim 12 or 13, wherein the carriage has one or more stops configured to prevent the one or more wings from rotating beyond the engaging position from the disengaging position.
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15. Seawater intake system according to any of claims 11 – 14, wherein the number of guide rails of the one or more guide rails is at least two, wherein the carriage is engageable with the guide rails so as to be constrained by the guide rails when the carriage is in between the guide
30 rails.

16. Seawater intake system according to any of claims 8 – 15, wherein at least some of the carriages are attached or attachable to the flexible hose.
- 5 17. Seawater intake system according to claim 16, wherein the flexible hose, in particular a distal section thereof, at least partly forms the distal section of the seawater channel, preferably wherein at least some of the carriages are attached or attachable to the distal section of the flexible hose.
- 10 18. Seawater intake system according to any of the preceding claims, further comprising a hose reel to be arranged at the hull and configured for at least the proximal section of the seawater channel to be reeled thereon.
- 15 19. Seawater intake system according to any of the preceding claims, wherein the distal section of the seawater channel has a channel length of at least 4 meters, preferably at least 6 meters, more preferably at least 8 meters, measured from the outlet of the submersible pump.
- 20 20. Seawater intake system according to any of the preceding claims, wherein the distal section of the seawater channel has a channel length of at most 30 meters, preferably at most 25 meters, more preferably at most 20 meters.
- 25 21. Seawater intake system according to any of the preceding claims, wherein the proximal section of the seawater channel has a channel length of at least 20 meters, preferably at least 30 meters, more preferably at least 40 meters.

22. Jack-up vessel provided with a seawater intake system according to any of the preceding claims, wherein the proximal end of the seawater channel is arranged at the hull.
- 5 23. Jack-up vessel according to claim 22, wherein the proximal end of the seawater channel is liquidly connected to a seawater tank of the jack-up vessel so as to allow seawater to flow from the seawater channel to the seawater tank.
- 10 24. Method of operating a jack-up vessel according to any of claims 22 – 23, comprising:
- at an offshore location, performing jacking to lower the legs to the sea floor and raise the hull to a level above the sea surface;
 - during the jacking and/or while the hull is raised to the level

15 above the sea surface, lowering the submersible pump with respect to the hull so as to become submersed in the sea, while the distal end of the seawater channel is connected to the outlet of the submersible pump; and

 - before and/or during the lowering of the submersible pump,

20 bending stiffness to the distal section of the seawater channel while the distal section is below the level of the hull.
25. Method according to claim 24 as dependent from claim 2, wherein the adjusting of the adjustable stiffening arrangement comprises
- 25 assembling the rigid pipe as part of the adjustable stiffening arrangement and preferably as part of the distal section of the seawater channel.
26. Method according to claim 24 or 25 as dependent from claim 8, wherein the adjusting of the adjustable stiffening arrangement comprises

causing the carriages to engage with the one or more guide rails, preferably so as to be constrained by the one or more guide rails.

27. Method according to claim 26 as dependent from claim 12,
5 wherein the causing of the carriages to engage with the one or more guide rails comprises causing the one or more wings of the respective carriage to rotate from the disengaging position to the engaging position so as to engage with the one or more guide rails, and preferably securing the one or more wings in the engaging position.

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28. Method according to any of claims 24 – 27 as dependent from claim 17, wherein the hose reel is operated to reel out at least part of the proximal section to allow the submersible pump to be lowered, in particular under influence of gravity.

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29. Method according to any of claims 24 – 28, wherein after the jacking and the lowering of the submersible pump, the distal section provided with the increased bending stiffness extends to above the sea surface.

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30. Method according to any of claims 24 – 29, further comprising at least partly reversing the adjusting of the adjustable stiffening arrangement to reduce the stiffness of the distal section to allow the submersible pump and the legs to be raised with respect to the hull.

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