

Debris protection system for a propeller shaft of a vessel**FIELD OF THE INVENTION**

The present invention relates to a sealing system for a driven shaft, also primary
5 shaft, in an underwater application. Such a drive shaft can for example be part of a vessel
or a turbine drive line for tidal energy.

BACKGROUND OF THE INVENTION

10 Technical seals in underwater applications are prone to pollution. Therefore, a dirt
barrier is often arranged upstream, concerning the flow of dirt, to avoid dirt from entering
the technical seal. Upstream is to say that the barrier is the first line of defence against
dirt. Known dirt barriers have a problem in that dirt accumulates between the dirt barrier
and the technical seal.

15 NL2013406 is an example of a technical seal and concerns a sealing structure for a
rotatable shaft comprises a housing with an annular cavity on an inside of the housing;
and a cartridge which sits within the annular cavity and is able to move radially within the
annular cavity. The cartridge comprises a plurality of annular sealing elements to seal
against the rotatable shaft.

20 DE2930462C2 relates to a seal for a grease-lubricated shaft. DE2930462C2
provides a sealing ring to protect the downstream seal from e.g., mud, abrasive particles,
dust etc.

SUMMARY OF THE INVENTION

25 The invention has for its object to provide an underwater sealing system that
reduces accumulation of dirt approximate a technical seal.

Therefore, according to a first aspect of the invention, there is provided an
underwater sealing system for providing a dirt barrier between a rotatable shaft and a
30 stationary member, the sealing system comprising an annular member for extending
around the rotatable shaft, wherein the annular member comprises;

a body section having a sealing contact surface extending between an inner
circumference and an outer circumference of the annular member, wherein, in use,

the sealing contact surface is facing the stationary member for providing lubricated sealing contact, wherein the body section comprises a plurality of recesses extending from the sealing contact surface into the body section and open toward the stationary member for receiving dirt from between the annular member and the stationary member into the plurality of recesses, and

a coupling section for contacting the rotatable shaft such that the annular member rotates with the rotatable shaft,

wherein at least one recess of the plurality of recesses extends in a radial direction.

The at least one recess of the plurality of recesses extending in a radial direction, facilitates transport of dirt away from the shaft during rotation of the shaft. The dirt is transported to the environment, usually to seawater. This importantly reduces accumulation of dirt between the annular member and the stationary member.

In other words, the at least one recess of the plurality of recesses extending in a radial direction, enables separation of dirt and water by density. Dirt is accumulated in a recess at a side of the recess proximate the outer circumference. It will be clear that normally, all of the recesses of the plurality of recesses extends in a radial direction to improve the effect of the separation of dirt and water.

Normally, the coupling section contacts the rotatable shaft by friction to rotate the annular member. Therefore, the coupling section comprises a clamping section. Any other suitable way of coupling the annular member with the shaft is conceivable, like for example a form closed connection. Thus, the coupling section in other words provides a coupling fixture between the shaft and the annular member. The coupling fixture can function based on coupling by form or by force. In a steady state, the annular member rotates in unity with the rotatable shaft. The coupling section may be coupled with the shaft through a so-called liner. In that case, the coupling section contacts the liner. Such a liner is often mounted on the shaft to protect the shaft. The liner, also referred to as a sleeve, is replaceable if required.

The underwater sealing system for providing a dirt barrier, functions as an upstream first point of attack against dirt that may otherwise enter a downstream technical sealing that is more delicate. An example of such a technical sealing is a flushing sealing system having flushed chambers between lip-seals. The underwater sealing system for providing a dirt barrier thus functions in conjunction with a technical sealing system. The

sealing system functions as a dirt barrier and can therefore be regarded a sealing system however, often, the underwater sealing system for providing a dirt barrier and the technical sealing system together form a sealing assembly. The technical sealing provides sealing of liquid and can withstand a certain pressure while the dirt barrier protects the
5 technical sealing.

The underwater sealing system provides a dirt barrier between a rotatable shaft and a stationary member. The rotatable shaft is for example a drive shaft of a ship's propeller. The stationary member is for example a part of a technical seal that separates
10 oil from the water outside the ship.

The body section of the annular member has a sealing contact surface extending between an inner circumference and an outer circumference of the annular member. It will be clear that in use, the sealing contact surface contacts an associated counter surface of the stationary member. The contact between the sealing contact surface and the
15 associated counter surface includes lubricated sealing contact. This means that during operation a film of water is formed between all or at least a part of the sealing contact surface and the associated counter surface.

In an embodiment of the underwater sealing system, the at least one recess
20 comprises a sidewall surface for entraining water in the at least one recess. The recess in combination with the sidewall surface for entraining water all the more promotes a radial flow of water to transport dirt away from the rotatable shaft to the environment. In other words, the recess in combination with the sidewall surface provides a pathway for transport of dirt from the rotatable shaft to the environment. This avoids accumulation of
25 dirt between the sealing system and a downstream technical seal. In addition, the radial flow provides a pressure drop between the annular member and a counterpart, which is a stationary member. This pressure drop prevents dislocation of the annular member from the stationary member and can also compensate for axial shaft movement with respect to the stationary member.

30

In an embodiment of the underwater sealing system, the annular member comprises a mass distribution such that during rotation of the rotatable shaft, deformation of the annular member flexes the body section away from the stationary member to at

least partly open the at least one recess of the plurality of recesses and allow dirt to leave the at least one recess to the environment and away from the rotatable shaft. In other words, the mass distribution facilitates deformation during rotation. The opening of the recess enables to transport dirt out of the recess and to the seawater.

5 The improved capability of the annular member to deform, all the more allows dirt to leave the at least one recess to the environment and away from the rotatable shaft. The combination of the plurality of recesses and the ability of the annular member to deform, facilitates sealing during standstill of the rotatable shaft and transport of dirt away from the shaft during rotation of the shaft. This importantly reduces accumulation
10 of dirt between the annular member and the stationary member.

 In an embodiment of the underwater sealing system, the annular member comprises a flexible material, preferably one or more of a rubber, a flexible polyurethane, an elastomer, NBR, NBR80, or the like. The annular member comprising a flexible
15 material all the more improves capability of the annular member to deform. The NBR80 rubber is merely an example, important is that the annular member is able to deform by angular velocity of the annular member caused by rotation of the shaft. The skilled person will understand that any suitable material is conceivable.

20 In an embodiment of the underwater sealing system, the annular member comprises a weakened section to facilitate deformation of the annular member. The weakened section all the more facilitates deformation of the annular member and flexing of the body section away from the stationary member to at least partly open the at least one recess of the plurality of recesses and allow dirt to leave the at least one recess to the
25 environment and away from the rotatable shaft. The weakened section may be within an interior volume of the annular member, like a hollow or a cavity. The weakened section may be at an interior and/or exterior surface. The weakened section may comprise one or more notches. A notch may extend along a part of the circumference or the entire circumference of the annular member. It will be clear that a lot of variations are
30 conceivable as long as the weakened section all the more facilitates deformation of the annular member.

In an embodiment of the underwater sealing system, the at least one recess of the plurality of recesses is open at a side facing toward the rotatable shaft. The at least one recess of the plurality of recesses being open at a side facing toward the rotatable shaft facilitates transport of dirt from the rotatable shaft to the environment because intake of dirt into the at least one recess is easier.

The at least one recess of the plurality of recesses being open at a side facing toward the rotatable shaft in combination with the recess being closed at an opposite side at an outer circumference of the annular member is in particular advantageous. In that case, transport of dirt is facilitated during rotation and the sealing system still performs a sealing function during standstill of the shaft and annular member.

The recess being open includes having an opening as well as being entirely open over the radial projected surface of the recess. It will be clear that normally transport of dirt is optimized if all recesses are open at a side facing toward the rotatable shaft. It is even conceivable that the at least one recess of the plurality of recesses is as well open at a side facing away from the rotatable shaft, which is the side of the recess at the outer circumference. In that case, the sealing system has an open connection between the shaft and the environment. This is optimal for transport during rotation, however during standstill, the liner and water repellent lip seal of a technical seal is exposed which may be a disadvantage. An assessment of desirability of an open connection must be done depending on the type of application and context of the sealing system.

In theory, a recess can have a closed circumference, thus the recess being only open towards the stationary object in an axial direction. Even then, there will be a radial outward flow that can transport dirt away from the shaft. However, transport of dirt will not be optimal in that case.

In an embodiment of the underwater sealing system, the at least one recess of the plurality of recesses comprises a section that expands in a radial outward direction. The at least one recess of the plurality of recesses expanding in a radial direction facilitates transport of dirt from the rotatable shaft to the environment even more. In addition, the section that expands may facilitate deformation of the annular member even more. The section that expands may be a tapered section.

In an embodiment of the underwater sealing system, the coupling section comprises a clamping section, and a centre of gravity of the annular member is offset from the location of a resultant clamping force of the clamping section. This all the more results in a bending moment and deformation of the annular member when the annular member rotates. The offset is best understood in a perspective of a side view wherein the offset is defined along the axis of rotation.

In an embodiment of the underwater sealing system, the body section comprises a solid ring section arranged along an outer circumference of the annular member, and which solid ring section extends between and or past the plurality of recesses seen in a radial outward direction. The body section comprising a solid ring section arranged along an outer circumference of the annular member and which extends past the plurality of recesses seen in a radial direction, all the more facilitates deformation of the annular member and flexing of the body section away from the stationary member to at least partly open the at least one recess of the plurality of recesses and allow dirt to leave the at least one recess to the environment and away from the rotatable shaft. In other words, the solid ring improves the effect of mass distribution of the annular member with a view of deformation of the annular member during rotation. In other words, the solid ring increases the offset of the centre of gravity of the annular member from the location of a resultant clamping force of the clamping section.

In an embodiment of the underwater sealing system, the annular member comprises a resilient transition section between the body section and the coupling section, wherein the resilient transition section is configured to allow axial suspension travel of the body section with respect to the coupling section, and wherein the resilient transition section preferably comprises a bellows. The resilient transition section allows the sealing system to accommodate axial free play of the rotatable shaft. In other words, sealing contact between the annular member and the stationary member is maintained within a window of axial tolerance. The resilient transition section being “between” the body section and the coupling section, means that the transition section couples the body section and the coupling section wherein the resilient transition section is configured to allow axial suspension travel of the body section with respect to the coupling section. A precise positioning of the resilient coupling between the body section and the coupling

section is not strictly required. A different position of the resilient coupling is conceivable as long as axial suspension travel of the body section with respect to the coupling section is allowed.

5 In an embodiment of the underwater sealing system, the at least one recess of the plurality of recesses comprises a height dimension h_1 in a radial direction of more than about 50% of a height dimension h_2 of the body section. The lower limit of the height of the recess in a radial direction assures sufficient radial flow and thus transport of dirt away from the shaft. It will be clear that the lower limit of the height dimension h_1 of the
10 recess in a radial direction may also depend on the rotational speed of the shaft.

 In an embodiment of the underwater sealing system, the height dimension h_1 of the at least one recess is between about 50% and about 80% of the height dimension h_2 of the body section. The upper limit of the height of the recess in a radial direction avoids
15 too much radial flow. Too much radial flow may cause a pressure drop over the height dimension h_2 of the body section and therefore a malfunctioning of a technical seal that is arranged upstream with respect to the annular member. It will be clear that the upper limit of the height of the recess in a radial direction may also depend on the rotational speed of the shaft.

20 In an embodiment of the underwater sealing system, the height dimension h_1 in the radial direction is between 50% - 95% of the height dimension h_2 of the body section, and the height dimension h_2 of the body section is less than 30 mm, preferably about 25 mm. This imposes an upper limit of the height h_1 of the recess in a radial direction and
25 this avoids too much pressure drop at the liner around the shaft.

 In an embodiment of the underwater sealing system, the at least one recess of the plurality of recesses comprises a radial axis of symmetry. In use, the radial axis of symmetry is aligned with a normal vector of the rotatable shaft. The radial axis of
30 symmetry enables to use the sealing system for both directions of rotation of the rotatable shaft.

In an embodiment of the underwater sealing system, the annular member comprises a first end, a second end and a connection section connecting the first and second end to form a closed annular member, wherein the connection section comprises one or more of an adhesive connection, a weld connection, a form closed connection. This facilitates installation of the sealing system around an already operational shaft.

In an embodiment of the underwater sealing system, the annular member is configured for mounting on a rotatable shaft having a diameter between 50 mm and 1250 mm.

10

In an embodiment of the underwater sealing system wherein the annular member is configured for operation on a rotatable shaft comprising a peripheral velocity between 0 m/s and 20 m/s. The peripheral velocity at a sealing contact surface is for example 5 m/s. The above peripheral velocities are typical in the context of ship propulsion. It will clear that velocities can be different for other applications.

15

In an embodiment of the underwater sealing system, the plurality of recesses extends in a circumferential direction over between 5% - 15% of a circumference of the annular member. This all the more facilitates transport of dirt away from the shaft during rotation of the shaft. Moreover, it turned out that in case of the plurality of recesses extending in a circumferential direction over between 5% - 15% of a circumference of the annular member, the body section having the sealing contact facing the stationary member still provides sufficient resistance to wear. Like for the height of the recess in a radial direction, the range of 5% - 15% may also depend on the rotational speed of the shaft.

20

It will be clear that the plurality of recesses extending in a circumferential direction over between 5% - 15% of a circumference of the annular member, concerns the sum of all of the recesses of the plurality of recesses. The width as well as the actual number of recesses may vary depending on a shaft diameter. For example for an annual member for a 330 mm shaft, the width of a recess is about 6 mm with an actual number of 16 recesses. In this example, the plurality of recesses extends in a circumferential direction over about 9,25% of the circumference of the annular member. In practice, the

30

shaft diameter can be between 125 mm up to 850 mm. The corresponding actual number of recesses is then between 6 and 42 assuming a similar width of a recess of about 6 mm.

According to a further aspect of the invention, and in accordance with the advantages and effects described herein above, there is provided an assembly of a sealing system as described above and a technical shaft sealing. Such a technical seal is typically a pressure seal and comprises a number of lip-seals in series and has a corresponding number of flushing chambers between adjacent lip-seals. The sealing system is arranged upstream to form a first line of defence against dirt.

10

According to a further aspect of the invention, and in accordance with the advantages and effects described herein above, there is provided a use of the sealing system according to any of the preceding claims in salt water, fresh water, sludge, or the like.

15

According to a further aspect of the invention, and in accordance with the advantages and effects described herein above, there is provided a method for servicing an underwater application comprising fitting a sealing system as described above around a rotatable shaft.

20

In an embodiment of the method for servicing, the method comprises connecting a first and second end of the annular member by gluing and/or welding to form a closed annular member.

25 BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described referring to the following schematical drawings wherein;

figure 1A shows a bottom view of a first embodiment of a sealing system according to the invention;

30 figure 1B shows a cross sectional side view of the sealing system of fig. 1A;
figure 1C shows a different cross sectional side view of the sealing system of fig. 1A;

figure 2 shows a detail of fig. 1A;

figure 3 shows an assembly of the sealing system of fig. 1A and a technical shaft sealing;

figure 4A shows a perspective view of a second embodiment of a sealing system according to the invention;

5 figure 4B shows a cross sectional side view of the sealing system of fig. 4A;

figure 5A shows a perspective view of a third embodiment of a sealing system according to the invention; and

figure 5B shows a cross sectional side view of the sealing system of fig. 5A.

The figures are meant for illustrative purposes only, and do not serve as restriction
10 of the scope or the protection as laid down by the claims.

DETAILED DESCRIPTION OF EMBODIMENTS

The following is a description of certain embodiments of the invention, given by
15 way of example only and with reference to the figures. A first embodiment of the invention is now described while referring to the figures 1A, 1B, 1C as well as figure 2. An underwater sealing system 1 is shown. The sealing system 1 functions underwater and is not suitable for dry-running. The sealing system 1 provides a dirt barrier between a rotatable shaft 22 and a stationary member. Typically, dirt is accumulated in front of any
20 sealing system. Therefore, it is known to apply an upstream pre-sealing that functions as a first line of defence against dirt that otherwise may compromise a downstream pressure seal. The sealing system comprises an annular member 2. The annular member 2 has a centre 16 and is ring-shaped around the centre. In use, the annular member 2 extends around a rotatable shaft 22 as shown in fig. 3.

25 The annular member 2 comprises a body section 3. The body section 3 is configured to make sealing contact with a counterpart. Therefore, the body section 3 has a sealing contact surface 8. The sealing contact surface extends between an inner circumference 6 and an outer circumference 7 of the annular member 2. In other words, the normal of the sealing contact surface 8 has an axial component or is axial with respect
30 to the annular member 2. In use, the sealing contact surface 8 is facing a stationary member 27 as shown in fig. 3 and provides lubricated sealing contact between the annular member 2 and the stationary member 27. In this case, the body section 3 comprises a solid ring section 29. The solid ring section 29 is arranged along an outer circumference

of the annular member 2. The solid ring section 29 extends between and or past the plurality of recesses 5 seen in a radial outward direction.

The body section 3 of the annular member 2 comprises a plurality of recesses 5. A
5 bottom view like in fig. 1A is to say that one looks into the plurality of recesses 5. A single recess 5 is now described. The recess 5 extends from the sealing contact surface 8 into the body section 3. The recess 5 is open toward the stationary member. That means, the recess 5 is open at its side that faces the stationary member. Therefore, the recess 5 is able to receive dirt from between the annular member 2 and the stationary member into
10 the recess 5. On top, a pressure drop in the recess improves sealing contact between the body section 3 and the stationary member 27.

In addition, the recess 5 is also open at an inner circumference of the annular member 2. This means that the recess 5 is open at a side facing toward the rotatable shaft 22 which all the more facilitates intake and transport of dirt away from the rotatable shaft
15 to the environment. In this case, all recesses 5 are open at a side facing toward the rotatable shaft 22.

The recess 5 extends in a radial direction 21. In other words, the recess 5 extends between the inner circumference 6 and the outer circumference 7 of the annular member 2. Therefore, during rotation of the annular member 2, dirt in the recess 5 is able to
20 accelerate within the recess 5 and is transported away from the shaft 22. In other words, the radial recess 5 in the body section 3 provides a pathway for transport of dirt from the rotatable shaft to the environment. To put it in a different way, the volume of the recess 5 allows separation on density resulting in movement of dirt, away from the shaft 22. The recess 5 allows the contents within the interior of the recess 5 to accelerate in a radial
25 direction of annular member over a height dimension h_1 as shown in fig. 2. In this case the h_1 is between 50% and 95% of the radial height h_2 of the body section 3. For example, the recess height h_1 is between 15 – 18 mm to provide a functional transport of dirt away from the shaft 22 when the shaft rotates at about 318 rpm, which is a circumferential velocity of 4 m/s for a typical liner diameter of 240 mm. In this example
30 the radial height h_2 of the body section 3 is about 25 mm.

The recess 5 comprises a sidewall 18, 19. In this case, the recess 5 comprises a pair of opposite sidewalls 18, 19. The sidewalls extend in a radial direction 21. Therefore,

the surface of the sidewalls 18, 19 are able to entrain water in the recess 5. The water in the recess 5 is therefore forced outward to the outer circumference 7. In this case the recess 5 comprises a radial axis 20 of symmetry.

The annular member 2 comprises a plurality of recesses 5 to increase the dirt
5 accommodating capacity of the sealing system 1. In this case, the plurality of recesses 5 are evenly distributed along the circumference of the annular member 2. This provides an even and continuous effect of the sealing system 1 along the circumference of a shaft.

The plurality of recesses 5 extends in a circumferential direction. The
circumferential direction corresponds to a direction of rotation of a shaft on which the
10 annular member 2 is applied. The plurality of recesses 5 extends in a circumferential direction over between 5% - 15% of a circumference of the annular member 2. The body section 3 providing the sealing contact surface 8 still maintains sufficient resistance to wear. The width as well as the actual number of recesses 5 may vary depending on a shaft diameter. The shaft diameter corresponds with the inner circumference 6 of the annular
15 member 3. The sealing system 1 as shown has an annular member 3 designed for a 330 mm shaft. Here, the width of a recess is about 6 mm with an actual number of 16 recesses 5. In practice, the shaft diameter can be between 125 mm up to 850 mm. The corresponding actual number of recesses is then between 6 and 42 assuming a similar width of a recess of about 6 mm. The width of a recess 5 corresponds to the distance
20 between the pair of opposite sidewalls 18, 19 as best shown in fig. 2.

The annular member 2 comprises a coupling section 4. The coupling section 4 is arranged at the inner circumference 6 of the annular member. In use, the coupling section 4 therefore faces the rotatable shaft 22. The coupling section 4 has a clamping surface 9.
25 In use, the coupling section 4 contacts the rotatable shaft. In use, the clamping surface 9 of the coupling section 4 contacts the rotatable shaft. In use, the coupling section 4 contacts the rotatable shaft to such a degree that the annular member 2 rotates in unity with the rotatable shaft 22.

The body section 3 predominantly extends at a right-angle with respect to the
30 rotatable shaft 22. The body section 3 transitions into the coupling section 4 through a transition section 30. The transition section 30 couples the body section 3 to the coupling section 4. The transition section 30 is resilient. The transition section 30 comprises a radius of curvature $r1$ that defines a rounding off of the transition section 30. The radius

of curvature r_1 can be chosen to facilitate deformation of the annular member 2. Deformation of the annular member 2 involves bending of the body section 3 with respect to the coupling section 4. This bending causes the body section 3 to reduce contact pressure with the stationary object 27. The radius of curvature r_1 is about 10 mm which
5 makes the annular member 2 more easy deformable compared to the embodiment of fig. 4B.

Figure 3 shows an assembly 34 of the sealing system 1 of fig. 1A and a technical shaft sealing 10. The assembly is operational under water 13. Such a technical seal 10 is
10 typically a pressure seal and comprises a number of lip-seals 11a, 11b in series and having a corresponding number of flushing chambers between the adjacent lip-seals. The technical seal 10 typically seals oil from water 13. The oil has a lubricating and/or cooling function at a ship side generally referred to with number 28. The sealing system 1 is
15 arranged upstream with respect to the technical seal 10 to form a first line of defence against dirt. The annular member 2 of the sealing system is clamped onto the rotatable shaft 22. The clamping force is generated by a spring element 12 that contacts the coupling section 4 of the annular member 2. In this case, the annular member 2 of the sealing system is clamped onto the rotatable shaft 22 via a liner 23.

The plurality of recesses 5 and the contact surface 8 of the body section 3 are
20 configured to seal against the stationary member 27 when resting against it. It will be clear that the ratio between contact surface 8 and projected area of recesses 5 is such that sealing effect is maintained during rotation and the recesses 5 entrain enough water to obtain a flushing effect. The plurality of recesses 5 are open at a side facing toward the liner 23. The plurality of recesses 5 are closed at an opposite side at an outer
25 circumference of the annular member 2. To close the plurality of recesses 5 at the opposite side, a wall section 35 contacts the stationary member 27.

As a result of the sealing system 1, the functioning of the technical seal 10 is improved. The improvement may include, longer life, longer service interval, improved sealing, etc.

30 The stationary object 27 is part of the technical shaft sealing 10. The technical shaft sealing 10 is stationary and connected to the ship side 28.

A second embodiment of the invention is now described while referring to the figures 4A and 4B. In this case, the recess 5 is open at one side. The recess 5 is open at an inner circumference of the annular member 2. The recess 5 is open at a side facing toward the rotatable shaft 22 to facilitate intake and transport of dirt away from the rotatable shaft to the environment. In other words, the recess 5 has an opening 14 that in use faces the shaft 22. The body section 3 predominantly extends at a right-angle with respect to the rotatable shaft 22. The body section 3 transitions into the coupling section 4 through a transition section 30. The transition section 30 is resilient. The transition section 30 comprises a radius of curvature r_2 that defines a rounding off of the transition section 30.

10 The radius of curvature r_2 is about 3 mm which makes the annular member 2 less deformable compared to the embodiment of fig. 1B.

A third embodiment of the invention is now described while referring to the figures 5A and 5B. The annular member 2 comprises a weakened section 15. The weakened section 15 is a notch in this case. The notch 15 facilitate deformation of the annular member 2. The notch 15 is arranged between the body section 3 and the coupling section 4.

As shown here in cross sectional side view, the centre of gravity 24 of the annular member 2 is offset from the location 25 of a resultant clamping force of the coupling section 4, in particular a clamping section thereof. The centre of gravity 24 of the annular member 2 is offset from the location 25 of a resultant clamping force of the coupling section 4 of a distance referred to with reference number 26. The distance or “arm” 26 facilitates deformation of the annular member 2 during rotation. Therefore, the annular member 2 comprises a mass distribution such that during rotation of the rotatable shaft, deformation of the annular member 2 flexes the body section 3 away from the stationary member to at least partly open the recess 5 and allow dirt to leave the recess 5 to the environment and away from the rotatable shaft 22 (not shown here).

Claims

1. Underwater sealing system (1) for providing a dirt barrier between a rotatable shaft (22) and a stationary member (27), the sealing system comprising an annular member (2) for
5 extending around the rotatable shaft, wherein the annular member comprises;
a body section (3) having a sealing contact surface (8) extending between an inner circumference (6) and an outer circumference (7) of the annular member, wherein, in use, the sealing contact surface is facing the stationary member for providing lubricated sealing contact, wherein the body section comprises a plurality of recesses (5) extending
10 from the sealing contact surface (8) into the body section (3) and open toward the stationary member for receiving dirt from between the annular member and the stationary member into the plurality of recesses, and
a coupling section (4) for contacting the rotatable shaft such that the annular member, in use, rotates with the rotatable shaft,
15 wherein at least one recess (5) of the plurality of recesses (5) extends in a radial direction.
2. The sealing system according to claim 1, wherein the at least one recess (5) comprises a sidewall (18, 19) surface for entraining water in the at least one recess.
20
3. The sealing system according to claim 1 or 2, wherein the annular member (2) comprises a mass distribution such that during rotation of the rotatable shaft, deformation of the annular member (2) flexes the body section (3) away from the stationary member to at least partly open the at least one recess (5) of the plurality of recesses and allow dirt to
25 leave the at least one recess to the environment and away from the rotatable shaft.
4. The sealing system according to any one of the preceding claims, wherein the annular member (2) comprises a flexible material, preferably one or more of a rubber, a flexible polyurethane, an elastomer, NBR, NBR80, or the like.
30
5. The sealing system according to any one of the preceding claims, wherein the annular member (2) comprises a weakened section (15) to facilitate deformation of the annular member.

6. The sealing system according to any one of the preceding claims, wherein the at least one recess of the plurality of recesses is open at a side (14) facing toward the rotatable shaft.
7. The sealing system according to any one of the preceding claims, wherein the at least one
5 recess of the plurality of recesses comprises a section that expands in a radial outward direction.
8. The sealing system according to any one of the preceding claims, wherein the coupling
10 section (4) comprises a clamping section, and wherein a centre of gravity (24) of the annular member (2) is offset from the location (25) of a resultant clamping force of the clamping section.
9. The sealing system according to any one of the preceding claims, wherein the body
15 section (3) comprises a solid ring section (29) arranged along the outer circumference (7) of the annular member, and which extends between and/or past the plurality of recesses seen in a radial outward direction.
10. The sealing system according to any one of the preceding claims, wherein the annular
20 member (2) comprises a resilient transition section (30) between the body section (3) and the coupling section (4), wherein the resilient transition section is configured to allow axial suspension travel of the body section with respect to the coupling section, and wherein the resilient transition section preferably comprises a bellow.
11. The sealing system according to any one of the preceding claims, wherein the at least one
25 recess of the plurality of recesses comprises a height dimension (h1) in a radial direction of more than about 50% of a height dimension (h2) of the body section (3).
12. The sealing system according to claim 11, wherein the height dimension (h1) in the radial
30 direction is between 50% - 95% of the height dimension (h2) of the body section (3), and the height dimension (h2) of the body section (3) is less than 30 mm, preferably about 25 mm.

13. The sealing system according to any one of the preceding claims, wherein at least one recess of the plurality of recesses comprises a radial axis (20) of symmetry.
14. The sealing system according to any one of the preceding claims, wherein the annular member comprises a first end (32), a second end (33) and a connection section (31) connecting the first and second end to form a closed annular member (2), wherein the connection section comprises one or more of an adhesive connection, a weld connection, a form closed connection.
15. The sealing system according to any of the preceding claims, wherein the annular member is configured for mounting on a rotatable shaft (22) having a diameter between 50 mm and 1250 mm.
16. The sealing system according to any of the preceding claims, wherein the annular member (2) is configured for operation on a rotatable shaft (22) comprising a peripheral velocity between 0 m/s and 20 m/s.
17. The sealing system according to any of the preceding claim, wherein the plurality of recesses (5) extends in a circumferential direction over between 5 - 15% of a circumference of the annular member.
18. Assembly (34) of a sealing system (1) according to any preceding claim and a technical shaft sealing (10).
19. Use of the sealing system according to any of the preceding claims 1 – 17 in salt water (13), fresh water, sludge, or the like.
20. A method for servicing an underwater application comprising fitting a sealing system (1) according to any one of the preceding claims 1 – 17 around a rotatable shaft (22).
21. A method according to claim 20, comprising connecting a first and second end of the annular member by gluing and/or welding to form a closed annular member.