several months, or even several years without any intervention whatsoever. Furthermore, it is preferable for the unit to be as sturdy as possible so as to reduce the number of essential maintenance operations.

Thus, the study of the clogging up by biofouling of filters intended for the great depths and the ultra-great depths is particularly important as it would enable the maintenance devices and procedures that are the most suitable for underwater seawater treatment units to be defined with a view to the water being used as injection water in an oil well.

The problem posed is equally true for any underwater installation which has a filtration system. There are numerous cases where the researchers and manufacturers need to operate filters underwater, for example in the seas and oceans. For example, the devices for pumping seawater for analysis purposes or for industrial purposes, or the devices for research into and study of shipwrecks at great depths can be cited.

By way of example, patent application US 2011/0132842 describes a device and a method for purifying water, notably for human consumption, using a combination of a reverse osmosis unit and a dehumidification unit. Another example is given by patent application CN 101844002 which describes a filtration method and device which enable water samples to be taken and analyzed in-situ. However, none of said documents neither discloses nor even suggests a method for evaluating the clogging up of filters in-situ.

It is in said context that the inventors have developed a method for evaluating the operation of filters, which enables, using an underwater testing device, the clogging up of filters to be studied directly in the real underwater environment.

BRIEF DESCRIPTION OF THE INVENTION

The object of the present ~~invention~~disclosure, among other things, is a method for testing an underwater filtration system including at least one filter, said method including the steps consisting in:

- introducing a flow of water into an underwater testing device via a water inlet, said underwater testing device including said filter;

- bringing said flow in the underwater testing device up to said filter;

- obtaining a filtrate downstream of said filter and discharging said filtrate into the environment via a discharge pipe;

said underwater testing device being placed underwater at a depth of at least 500 meters.

Furthermore, the underwater testing device including:

- at least one filter;
- a water inlet which is suitable for introducing a flow of water sampled from the environment of the device into the underwater device;
- a pipe connecting said water inlet and said filter;
- a discharge pipe downstream of said filter that is suitable for discharging the filtrate into the environment of the device;
- at least one pump which is suitable for filtering of the flow of water across said filter;
- a means for supplying the device with power,

is also an object of the present ~~invention~~disclosure.

The ~~invention~~ disclosure further concerns the use of said underwater testing device in order to follow the evolution of the fouling of a filter placed in an aquatic environment in real conditions.

In one aspect of the disclosure, there is provided a method for testing an underwater filtration system including one or several filters, said method including the steps consisting in: introducing a flow of water into an underwater testing device via a water inlet, said underwater testing device including said filter(s); bringing said flow in the underwater testing device up to said filter(s); obtaining a filtrate downstream of said filter(s) and discharging said filtrate into the environment via a discharge pipe; said underwater testing device being placed underwater at a depth of at least 500 meters.

In another aspect, there is provided an underwater device including: at least one filter; a water inlet which is suitable for introducing a flow of water sampled from the environment of the device into the underwater device; a pipe connecting said water inlet and said filter; a discharge pipe downstream of said filter; at least one pump which is suitable for filtering of the flow of water across said filter; a means for supplying the device with power.

In still another aspect, there is provided an under-water device including in order with respect to the normal flowing of the water flow in the system: a water

inlet; a pipe connecting said water inlet and a pre-filter; said pre-filter; a pipe connecting said pre-filter and desulfation membrane; said nanofiltration membrane for desulfation; then on the one hand, a discharge pipe downstream of said desulfation membrane; and on the other hand, a discharge pipe for the retentate of the desulfation membrane.

DESCRIPTION OF THE FIGURES

Figure 1 is a schematic representation of an embodiment of an underwater testing device according to the invention.

Figure 2 is a schematic representation of another embodiment of an underwater testing device according to the invention.

Figure 3 is a schematic representation of an underwater testing device within the context of its use.

DETAILED DESCRIPTION OF THE INVENTION

In the present application, the expression "between ... and ... inclusive" must be understood as including the limit values.

The method for testing an underwater filtration system according to the invention first of all includes a step consisting in introducing a flow of water into an underwater testing device via a water inlet. The underwater testing device, which is also an object of the invention, is characterized among other things by the fact that

CLAIMS

1. A method for testing an underwater filtration system including at least one filter, said method including the steps consisting in:

- introducing a flow of water into an underwater testing device via a water inlet, said underwater testing device including said filter;

- bringing said flow in the underwater testing device up to said filter;

- obtaining a filtrate downstream of said filter and discharging said filtrate into the environment via a discharge pipe;

said underwater testing device being placed underwater at a depth of at least 500 meters.

2. The method as claimed in claim 1, characterized in that said method further includes a step consisting in:

- measuring the difference in pressure between the upstream side and the downstream side of the filter; and

- recording said measurement of the difference in pressure in a storage means situated in the underwater testing device or transmitting said measurement of the difference in pressure to a receiving means situated outside the underwater testing device.

3. The method as claimed in claim 2, characterized by the fact that the measurement of the difference in pressure is taken in a repetitive manner, in a preferred manner at a frequency of between once a second and once an hour inclusive, each measurement obtained being recorded in the storage means situated in the underwater testing device or being transmitted to the receiving means situated outside the underwater testing device.

4. The method as claimed in any one of claims 1 to 3, characterized in that the underwater testing device is supplied with power from the surface via an umbilical.

5. The method as claimed in any one of claims 1 to 3, characterized in that the underwater testing device is electrically autonomous and is supplied with power thanks to a battery situated in the underwater testing device.

6. The method for testing as claimed in any one of claims 1 to 5, further including the steps consisting in sampling at least one flow chosen from among:

- the flow upstream of the filter(s); and
- the flow downstream of the filter(s);

and in storing said sample in a storage means situated in the underwater testing device or in sending said sample to a receiving means situated outside the underwater testing device.

7. The method for testing as claimed in any one of claims 1 to 6, characterized in that said method further includes a recycling step consisting in bringing at least part of the filtrate obtained at the outlet of the filter up to the flow of water which is intended to cross said filter.

8. The method for testing as claimed in any one of claims 1 to 7, characterized in that said method further includes a step for backwashing the filter.

9. The method for testing as claimed in any one of claims 1 to 8, characterized in that said method further includes a step consisting in injecting a biocide into a pipe which connects the water inlet and the filter, in a preferred manner close to the water inlet.

10. The method for testing as claimed in any one of claims 1 to 9, further including a preliminary step consisting in submerging the underwater testing device into an aquatic environment at a depth of at least 500 meters, then leaving the device underwater for a duration of between 1 and 12 months inclusive, then bringing the device to the surface.

11. An underwater testing device including:

- at least one filter;

- a water inlet which is suitable for introducing a flow of water sampled from the environment of the device into the underwater device;

- a pipe connecting said water inlet and said filter;

- a discharge pipe downstream of said filter that is suitable for discharging the filtrate into the environment of the device;

- at least one pump which is suitable for filtering of the flow of water across said filter;

- a means for supplying the device with power.

12. The underwater testing device as claimed in claim 11, characterized in that the filter is a filtration membrane.

13. The underwater testing device as claimed in claim 12, characterized in that the filter is a nanofiltration membrane or a reverse osmosis membrane.

14. The underwater testing device as claimed in claim 13, characterized in that the filter is a membrane for desulfation.

15. The underwater testing device as claimed in any one of claims 11 to 14, characterized in that said device further includes a means for measuring the difference in pressure between the upstream side and the downstream side of said filter.

16. The underwater testing device as claimed in any one of claims 11 to 15, characterized in that the means for supplying the device with power is an umbilical which connects the underwater testing device to a power source.

17. The underwater testing device as claimed in any one of claims 11 to 15, characterized in that the means for supplying the device with power is a battery which is situated in said device.

18. The underwater testing device as claimed in any one of claims 11 to 17, characterized in that the filter is a nanofiltration membrane for desulfation, and in

that the device further includes a pre-filter, said pre-filter being situated upstream of said nanofiltration membrane for desulfation.

19. The underwater testing device as claimed in any one of claims 11 to 18, characterized in that the device further includes a recycling circuit which connects the discharge pipe downstream of the filter to the pipe upstream of the filter.

20. The underwater testing device as claimed in any one of claims 11 to 19, characterized in that the device includes a backwash circuit.

21. The underwater testing device as claimed in any one of claims 11 to 20, characterized in that the filtration unit further includes one or several biocide tanks, at least one of said tanks being suitable for the injection of biocide into the pipe which connects the water inlet and the filter, in a preferred manner close to the water inlet.

22. The underwater testing device as claimed in any one of claims 11 to 21, characterized in that said device includes at least one sampling pipe for one or several flows chosen from among:

- the flow upstream of the filter(s); and
- the flow downstream of the filter(s);

and in that said device further includes a means for storing said samples situated in the underwater testing device and/or a means for sending said samples to a receiving means situated outside the underwater testing device.

23. Use of the underwater testing device such as defined in any one of claims 11 to 22 in order to follow the evolution of the fouling of a filter placed in an aquatic environment in real conditions.

CLAIMS

1. A method for testing an underwater filtration system including one or several filters, said method including the steps consisting in:

- introducing a flow of water into an underwater testing device via a water inlet, said underwater testing device including said filter(s);

- bringing said flow in the underwater testing device up to said filter(s);

- obtaining a filtrate downstream of said filter(s) and discharging said filtrate into the environment via a discharge pipe;

said underwater testing device being placed underwater at a depth of at least 500 meters.

2. The method as claimed in claim 1, characterized in that said method further includes a step consisting in:

- measuring the difference in pressure between the upstream side and the downstream side of the filter(s); and

- recording said measurement of the difference in pressure in a storage means situated in the underwater testing device or transmitting said measurement of the difference in pressure to a receiving means situated outside the underwater testing device.

3. The method as claimed in claim 2, characterized by the fact that the measurement of the difference in pressure is taken in a repetitive manner, in a preferred manner at a frequency of between once a second and once an hour inclusive, each measurement obtained being recorded in the storage means situated in the underwater testing device or being transmitted to the receiving means situated outside the underwater testing device.

4. The method for testing as claimed in any one of claims 1 to 3, further including the steps consisting in sampling at least one flow chosen from among:

- the flow upstream of the filter(s); and

- the flow downstream of the filter(s);

and in storing said sample in a storage means situated in the underwater testing device or in sending said sample to a receiving means situated outside the underwater testing device.

5. The method for testing as claimed in any one of claims 1 to 4, characterized in that said method further includes a recycling step consisting in bringing at least part of the filtrate obtained at the outlet of the filter up to the flow of water which is intended to cross said filter.

6. The method for testing as claimed in any one of claims 1 to 5, characterized in that said method further includes a step for backwashing the filter.

7. The method for testing as claimed in any one of claims 1 to 6, characterized in that said method further includes a step consisting in injecting a biocide into a pipe which connects the water inlet and the filter, in a preferred manner close to the water inlet.

8. The method for testing as claimed in any one of claims 1 to 7, further including a preliminary step consisting in submerging the underwater testing device into an aquatic environment at a depth of at least 500 meters, then leaving the device underwater for a duration of between 1 and 12 months inclusive, then bringing the device to the surface.

9. The method for testing as claimed in any one of claims 1 to 8, for following the evolution of the fouling of said filter(s) placed in aquatic environment.

10. An underwater device including:

- at least one filter;
- a water inlet which is suitable for introducing a flow of water sampled from the environment of the device into the underwater device;
- a pipe connecting said water inlet and said filter;
- a discharge pipe downstream of said filter;

- at least one pump which is suitable for filtering of the flow of water across said filter;

- a means for supplying the device with power.

11. The underwater device as claimed in claim 10, characterized in that the filter is a membrane for desulfation.

12. The underwater device as claimed in claims 10 or 11, characterized in that said device further includes a means for measuring the difference in pressure between the upstream side and the downstream side of said filter.

13. The underwater device as claimed in any one of claims 10 to 12, characterized in that the filter is a nanofiltration membrane for desulfation, and in that the device further includes a pre-filter, said pre-filter being situated upstream of said nanofiltration membrane for desulfation.

14. The underwater device as claimed in any one of claims 10 to 13, characterized in that the device further includes a recycling circuit which connects the discharge pipe downstream of the filter to the pipe upstream of the filter.

15. The underwater device as claimed in any one of claims 10 to 14, characterized in that the device includes a backwash circuit.

16. The underwater device as claimed in any one of claims 10 to 15, characterized in that the filtration unit further includes one or several biocide tanks, at least one of said tanks being suitable for the injection of biocide into the pipe which connects the water inlet and the filter, in a preferred manner close to the water inlet.

17. The underwater device as claimed in any one of claims 10 to 16, characterized in that said device includes at least one sampling pipe for one or several flows chosen from among:

- the flow upstream of the filter(s); and
- the flow downstream of the filter(s);

and in that said device further includes a means for storing said samples situated in the underwater testing device and/or a means for sending said samples to a receiving means situated outside the underwater testing device.

18. An under-water device including in order with respect to the normal flowing of the water flow in the system:

- a water inlet;
- a pipe connecting said water inlet and a pre-filter;
- said pre-filter;
- a pipe connecting said pre-filter and desulfation membrane;
- said nanofiltration membrane for desulfation; then
- on the one hand, a discharge pipe downstream of said desulfation membrane; and on the other hand, a discharge pipe for the retentate of the desulfation membrane.