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(54) **Title**: AUTONOMOUS VALVE EROSION MONITORING

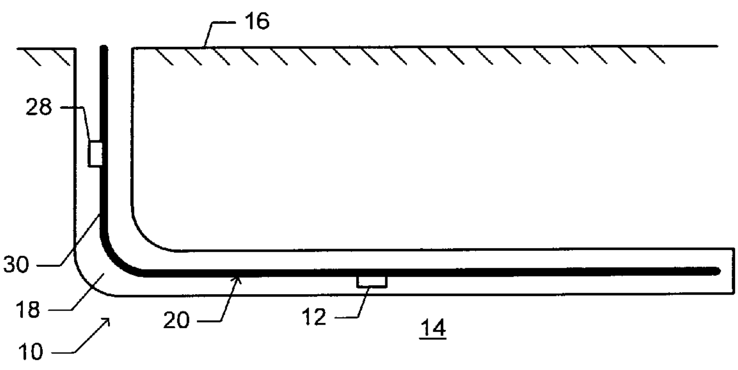

Fig. 1

(57) **Abstract**: The present invention relates to a method for monitoring any erosion of an autonomous valve (12), wherein the autonomous valve is adapted to control a flow of fluid (26) by exploiting at least one of the viscosity of the fluid, the Bernoulli effect, and any stagnation pressure, and wherein the autonomous valve includes at least one component (22, 24) exposed to the flow and comprising a specific material, which method comprises: detecting in fluid (30) having passed the autonomous valve any of the specific material (A), whereby detection of the specific material indicates erosion of the autonomous valve. The present invention also relates to a system and an autonomous valve which allow monitoring of any erosion of the valve.

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Autonomous valve erosion monitoring

The present invention relates to a method, system, and autonomous valve which allow monitoring of any erosion of the valve.

WO2008004875 discloses a self-adjustable (autonomous) valve or flow control device for controlling the flow of a fluid from one space or area to another, in particular useful for controlling the flow of fluid, i.e. oil and/or gas including any water, from a reservoir and into a production pipe of a well in the oil and/or gas reservoir, which production pipe includes a lower drainage pipe preferably being divided into at least two sections each including one or more inflow control devices which communicates the geological production formation with the flow space of the drainage pipe, wherein the control device is a separate or integral part of the fluid flow control arrangement, including a disc or freely movable controlling body being provided in a recess of the pipe wall or being provided in a separate housing body in the wall, the disc or controlling body facing the outlet of an aperture or hole in the centre of the recess or housing body and being held in place in the recess or housing body by means of a holder device or arrangement, thereby forming a flow path where the fluid enters the control device through the central aperture or inlet flowing towards and along the disc or body and out of the recess or housing.

Autonomous valves like the valve in WO2008004875 typically operates in an environment where eroding particles (in particular sand) gradually can deteriorate the functionality of the valve. The reason for this in that material will be removed from the surface of components of the valve that are subjected to erosion, and geometrical deviations of components may thereby occur that negatively affect the performance of the valve. For autonomous valves like the valve in WO2008004875, the most affected components are the freely movable body and the holder device (valve seat).

It is an object of the present invention to provide a method, system, and autonomous valve which allow monitoring of any erosion of the valve.

This, and other objects that will be apparent from the following description, is achieved by a method, system, and autonomous valve according to the appended independent claims. Embodiments are set forth in the dependent claims.

According to an aspect of the present invention, there is provided a method for monitoring any erosion of an autonomous valve, wherein the autonomous valve is adapted to control a flow of fluid by exploiting at least one of the viscosity of the fluid, the Bernoulli effect, and any stagnation pressure, and wherein the autonomous valve includes at least one component exposed to the flow and comprising a specific material, which method comprises: detecting in fluid having passed the autonomous valve any of the specific material, whereby detection of the specific material indicates erosion of the autonomous valve.

The present invention allows remote monitoring of any erosion of an autonomous valve without direct, on-site inspection of the autonomous valve. Hence, the erosion of the valve may be monitored even though the autonomous valve may be in use or operation for instance in an oil well. By knowing about the erosion, the valve may be replaced or repaired or shut down or bypassed in due time, before its functionality has deteriorated (too much). Also, knowing about the erosion of the valve may help engineers to further develop the valve to reduce or prevent erosion in the future.

The at least one component can be made of the specific material, it may be coated with the specific material, or it may have the specific material underlying another material.

The at least one component may have an outer layer and one or more underlying layers, each layer including a different specific material, wherein detection of the different specific material(s) indicates the amount or degree of erosion of the autonomous valve. For instance detection of a material A from the outer layer indicates a first degree of erosion, while detection of an underlying material B indicates a severer or deeper erosion.

The autonomous valve may form part of a hydrocarbon production arrangement, wherein the specific material(s) differ(s) from the other materials that the hydrocarbon production arrangement is made of or handles, thereby making the specific material(s) uniquely identifiable.

Further, several autonomous valves may each include at least one component comprising a specific material unique for that autonomous valve, wherein detection of the unique specific material(s) in the fluid from the several autonomous indicates which autonomous valve/valves that is/are eroding. For instance, autonomous valve (a) may include material A and autonomous valve (b) may include material B, whereby detection of material A indicates erosion of valve (a), while detection of material B indicates erosion of valve (b).

The at least one component may be a valve seat and/or a movable body arranged in the valve seat of the autonomous valve.

The specific material(s) may be selected from the group comprising: titan, nickel, steel, titan alloy, nickel alloy, and tungsten carbide. Hence, the specific material may be (at least substantially) pure or a composition.

According to another aspect of the present invention, there is provided a system, comprising: an autonomous valve adapted to control a flow of fluid by exploiting at least one of the viscosity of the fluid, the Bernoulli effect, and any stagnation pressure, wherein the autonomous valve includes at least one component which comprises a specific material and which in use is exposed to the flow; and means adapted to detect in fluid having passed the autonomous valve any of the specific material, whereby detection of the specific material indicates erosion of the autonomous valve. This aspect may exhibit the same or similar features and technical effects as the previously described aspect of the invention.

The at least one component can be made of the specific material, it may be coated with the specific material, or it may have the specific material underlying another material.

The at least one component may have an outer layer and one or more underlying layers, each layer including a different specific material, wherein said means is adapted to detect the different specific materials in the fluid having passed the autonomous valve, for indicating the amount or degree of erosion of the autonomous valve.

The autonomous valve may form part of a hydrocarbon production arrangement, wherein the specific material(s) differ(s) from the other materials that the hydrocarbon production system is made of or handles, at least upstream of the detection means or a detection point, thereby making the specific material(s) uniquely identifiable.

The system may comprise at least one further autonomous valve, wherein each autonomous valves includes at least one component comprising a specific material unique for that autonomous valve, wherein said means is adapted detect the unique specific materials in the fluid from the autonomous valves, for indicating which autonomous valve/valves that is/are eroding.

The at least one component may be a valve seat and/or a movable body arranged in the valve seat of the autonomous valve.

The specific material(s) may be selected from the group comprising: titan, nickel, steel, titan alloy, nickel alloy, and tungsten carbide.

According to yet another aspect of the present invention, there is provided an autonomous valve, comprising a valve seat and a movable body arranged in the valve seat for controlling a flow of fluid through the autonomous valve by exploiting at least one of the viscosity of the fluid, the Bernoulli effect, and any stagnation pressure, wherein at least one component of the autonomous valve, which at least one component in use is exposed to the flow, has a first outer material and a second different underlying material. This aspect may exhibit the same or similar features and technical effects as the previously described aspects of the invention.

The at least one component may be the valve seat and/or the movable body.

At least one of said materials may be selected from the group comprising: titan, nickel, steel, titan alloy, nickel alloy, and tungsten carbide.

These and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing currently preferred embodiments of the invention.

Fig. 1 schematically illustrates a system according to an embodiment of the invention.

Fig. 2 is a cross-sectional side view of an autonomous valve in the system of fig. 1.

Fig. 3 schematically illustrates a system according to another embodiment of the invention.

Fig. 4 is a cross-sectional side view of an autonomous valve according to an embodiment of the invention.

Fig. 1 schematically illustrates a system 10 according to an embodiment of the invention. The present invention may be applied onshore or offshore (subsea).

The system 10 comprises at least one autonomous valve 12. The autonomous valve 12 forms part of a hydrocarbon production arrangement used to produce oil and/or (natural) gas from a formation or reservoir 14. The reservoir 14 may be for instance be located under the earth surface or the sea floor 16. A hole or wellbore 18 is provided from the earth surface or sea floor 16 to the reservoir 14. A production pipe 20 of the hydrocarbon production arrangement is placed in the wellbore 18 for providing a flow path for hydrocarbons and other fluids through the wellbore 18. The exemplary production pipe 20 extends into the reservoir 14, and has an at least partly horizontal orientation. The autonomous valve 12 is arranged in the pipe wall of the production pipe 20.

The autonomous valve 12 is shown in more detail in fig. 2. The autonomous valve 12 includes a valve seat 22 and a movable body 24 arranged in the valve seat for controlling a flow of fluid 26 (indicated by arrows in fig. 2, the fluid is typically oil, gas, and/or water) from the reservoir 14 into the production pipe 20. An autonomous valve of this type is generally disclosed in WO2008004875, the contents of which herein is incorporated by reference. The valve 12 may control the flow of fluid through the valve by exploiting at least one of the viscosity of the fluid, the Bernoulli effect, and any stagnation pressure.

The present autonomous valve 12 includes at least one component which is provided with (e.g. coated with) or completely made of a specific material A. The specific material A differs from the other materials that the hydrocarbon production arrangement is made of or handles. The specific material A may for instance be pure titan, pure nickel, a specific steel variant, a specific titan alloy, a specific nickel alloy, or tungsten carbide.

The at least one component provided with or made of the material A may for instance be the movable body 24, as in fig. 2. Alternatively, or complementary, at least one other component that in use or operation is exposed to the flow of fluid 26 through the autonomous valve 12 could be provided with or made of the material A, such as the valve seat 22.

Returning to fig. 1, the system 10 further comprises a detection means 28. The detection means 28 may for instance include a spectrometer, though it is envisaged that other techniques than spectroscopy also could be used for detecting the specific material(s).

During use or operation, the flow of fluid 26 through the autonomous valve 12 may cause erosion on components exposed to the flow, like the movable body 24. Hence, material A will be removed from the movable body 24. The removed material A (also called erosion product) follows the fluid 30 from the autonomous valve 12 towards the detection means 28 or a detection point downstream of the valve. In case the detection means 28 is a spectrometer, a sample is taken at the detection point downstream of the autonomous valve 12 and analysed in the spectrometer for detecting the specific material A. The sample should be taken early, before the fluid proceeds too far into production arrangement. The sample may for instance be taken in or nearby a separation equipment (not shown) of the hydrocarbon production arrangement. The detection means 28 may be adapted or used to detect the mere presence of material A, which indicates that erosion in the autonomous valve 12 is taking place. Also, the detection means 28 may be adapted or used to detect the amount of material A, which then indicates the amount or degree of erosion. Further, the detection can be continuous or discrete in time.

The present invention allows remote monitoring of any erosion of an autonomous valve without direct, on-site inspection of the autonomous valve. Hence, the erosion of the valve may be monitored even though the autonomous valve may be in use or operation for instance in an oil well. By knowing about the erosion, the valve may be replaced or repaired or shut down or bypassed in due time, before its functionality has deteriorated (too much). Also, knowing about the erosion of the valve may help engineers to further develop the valve to reduce or prevent erosion in the future.

Fig. 3 schematically illustrates a system 10 according to another embodiment of the invention. The system 10 in fig. 3 is similar to that in fig. 1, though it comprises several autonomous valves 12a-12c arranged along a length of the production pipe 20, as illustrated.

In the autonomous valve 12a, a component (e.g. the movable body) exposed to the flow of fluid through the valve is provided with or made of a specific material A. Likewise, the autonomous valve 12b includes a component with material B, and the autonomous valve 12c includes a component with material C. The materials A-C are different from each other, and they also differ from the other materials that the hydrocarbon production arrangement is made of or handles. Further, the detection means 28 is adapted to detect the different materials A-C in the combined fluid from the valves 12a-12c.

In use or operation, detection of material A by the detection means 28 indicates erosion of the autonomous valve 12a, detection of material B by the detection means 28 indicates erosion of the autonomous valve 12b, detection of material B by the detection means 28 indicates erosion of the autonomous valve 12c. By knowing what autonomous valve that originally contained what specific material, it becomes possible to differentiate which valve/valves that is/are eroding.

Fig. 4 is a cross-sectional side view of an autonomous valve 12 according to an embodiment of the invention. The autonomous valve 12 in fig. 4 is similar to that in fig. 2, though here the at least one component exposed to the flow of fluid through the valve has a first outer material A and a second different material B underlying the first material A. For example, the movable body 24 may include one outer(most) layer 32 made of a specific material A, while another layer or core 34 below the outer later 32 includes another specific material B. The outer later 32 should completely cover the other underlying layer or core 34. If the movable body 24 is a disc, the core or body of the disc could be made of material B, which core is completely coated with the material A. Again, the different specific materials (e.g. A and B) should also differ from the other materials in a hydrocarbon production arrangement which the autonomous valve is included in. Also, additional underlying layers of different materials could be provided for indicating various degrees of erosion.

When the autonomous valve in fig. 4 is used in a system as shown in fig. 1, the detection means 28 is adapted to detect at least one of the different materials A and B in the fluid from the autonomous valve, whereby detection of a material A from the outer layer 32 indicates a first degree of erosion, while detection of the underlying material B indicates a more sever or deeper erosion.

In alternative embodiment, the material A of the outer layer 32 may be a “regular” material of the exposed component in question, wherein only the underlying material B is detected using the detection means 28. Detection of material B indirectly indicates that the overlying material A as least partly has been eroded off the component in question.

The person skilled in the art will realize that the present invention by no means is limited to the embodiments described above. On the contrary, many modifications and variations and combinations are possible within the scope of the appended claims.

Claims

1. A method for monitoring any erosion of an autonomous valve (12), wherein the autonomous valve is adapted to control a flow of fluid (26) by exploiting at least one of the viscosity of the fluid, the Bernoulli effect, and any stagnation pressure, and wherein the autonomous valve includes at least one component (22, 24) exposed to the flow and comprising a specific material (A), which method comprises:

detecting in fluid (30) having passed the autonomous valve any of the specific material, whereby detection of the specific material indicates erosion of the autonomous valve.

2. A method according to claim 1, wherein the at least one component is made of the specific material, is coated with the specific material, or has the specific material underlying another material.

3. A method according to claim 1 or 2, wherein the at least one component has an outer layer (32) and one or more underlying layers (34), each layer including a different specific material (A, B), and wherein detection of the different specific material(s) indicates the amount or degree of erosion of the autonomous valve.

4. A method according to any preceding claim, wherein the autonomous valve forms part of a hydrocarbon production arrangement, and wherein the specific material(s) differ(s) from the other materials that the hydrocarbon production arrangement is made of or handles, thereby making the specific material(s) uniquely identifiable.

5. A method according to any preceding claim, wherein several autonomous valves (12a-c) each includes at least one component comprising a specific material (A, B, C) unique for that autonomous valve, and wherein detection of the unique specific material(s) in the fluid from the several autonomous indicates which autonomous valve/valves that is/are eroding.

6. A method according to any preceding claim, wherein the at least one component is a valve seat (22) and/or a movable body (24) arranged in the valve seat.

7. A method according to any preceding claim, wherein the specific material(s) is/are selected from the group comprising: titan, nickel, steel, titan alloy, nickel alloy, and tungsten carbide.

8. A system (10), comprising:

an autonomous valve (12) adapted to control a flow of fluid (26) by exploiting at least one of the viscosity of the fluid, the Bernoulli effect, and any stagnation pressure, wherein the autonomous valve includes at least one component (22, 24) which comprises a specific material (A) and which in use is exposed to the flow; and

means (28) adapted to detect in fluid (30) having passed the autonomous valve any of the specific material, whereby detection of the specific material indicates erosion of the autonomous valve.

9. A system according to claim 8, wherein the at least one component is made of the specific material, is coated with the specific material, or has the specific material underlying another material.

10. A system according to claim 8 or 9, wherein the at least one component has an outer layer (32) and one or more underlying layers (34), each layer including a different specific material (A, B), and wherein said means is adapted to detect the different specific materials in the fluid having passed the autonomous valve.

11. A system according to any one of claims 8 – 10, wherein the autonomous valve forms part of a hydrocarbon production arrangement, and wherein the specific material(s) differ(s) from the other materials that the hydrocarbon production system is made of or handles, at least upstream of the detection means or a detection point, thereby making the specific material(s) uniquely identifiable.

12. A system according to any one of the claims 8 – 11, comprising at least one further autonomous valve (12a-c), wherein each autonomous valves includes at least one component comprising a specific material (A, B, C) unique for that autonomous valve, wherein said means is adapted detect the unique specific materials in the fluid from the autonomous valves.

13. A system according to any one of the claims 8 – 12, wherein the at least one component is a valve seat (22) and/or a movable body (24) arranged in the valve seat.

14. A system according to any one of the claims 8 – 12, wherein the specific material(s) is/are selected from the group comprising: titan, nickel, steel, titan alloy, nickel alloy, and tungsten carbide.

15. An autonomous valve (12), comprising a valve seat (22) and a movable body (24) arranged in the valve seat for controlling a flow of fluid (26) through the autonomous valve by exploiting at least one of the viscosity of the fluid, the Bernoulli effect, and any stagnation pressure, wherein at least one component of the autonomous valve, which at least one component in use is exposed to the flow, has a first outer material (A) and a second different underlying material (B).

16. An autonomous valve according to claim 15, wherein the at least one component is the valve seat and/or the movable body.

17. An autonomous valve according to claim 15 or 16, wherein at least one of said materials is selected from the group comprising: titan, nickel, steel, titan alloy, nickel alloy, and tungsten carbide.

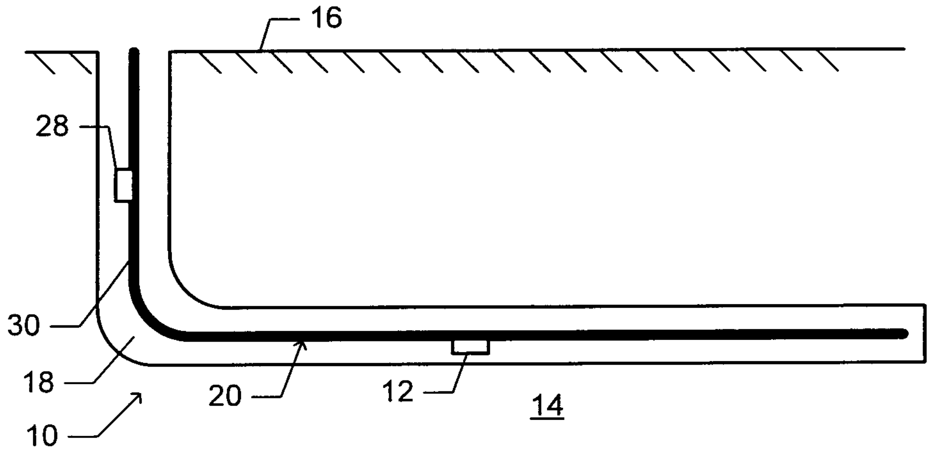

Fig. 1

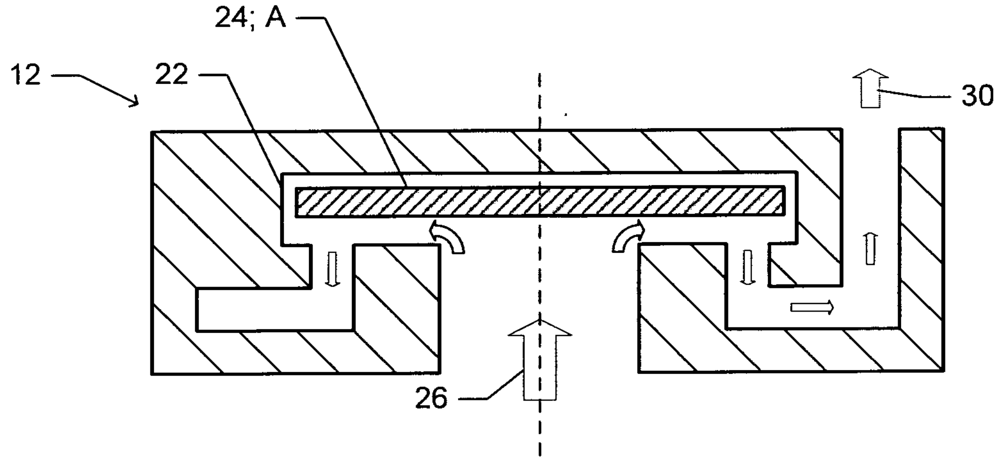

Fig. 2

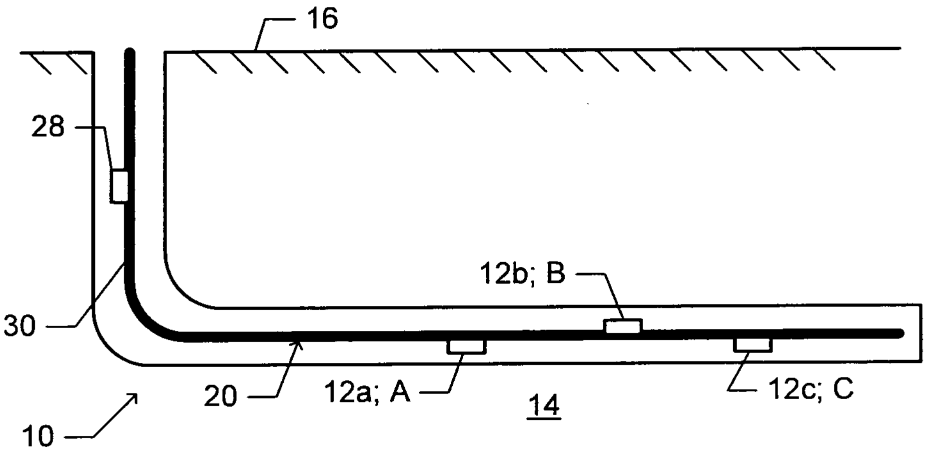

Fig. 3

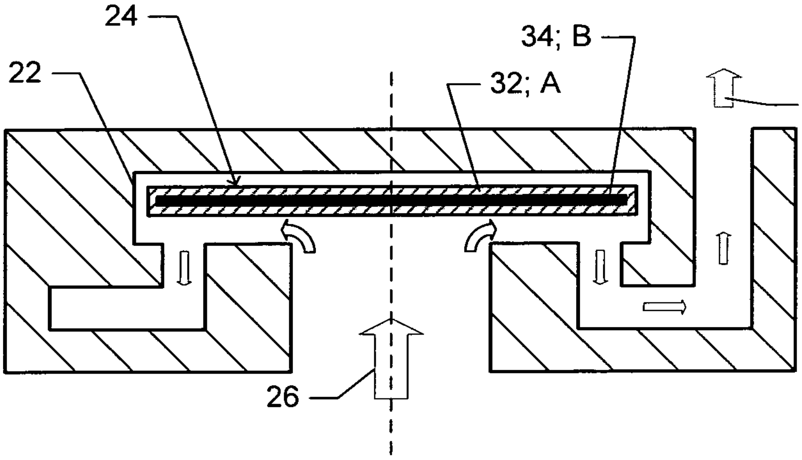

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/NO2010/000464

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16K37/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16K G01N E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 5 790 246 A (KUHNELL BRUCE THOMAS [AU] ET AL) 4 August 1998 (1998-08-04) column 1, line 7 - line 16 -----	1,2,4, 6-9,11, 13,14
X	US 2010/263873 A1 (TURNER DON [CA] ET AL) 21 October 2010 (2010-10-21) paragraph [0023] -----	15-17
X	US 2005/072578 A1 (STEELE DAVID JOE [US] ET AL) 7 April 2005 (2005-04-07) paragraph [0037] -----	15-17
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 August 2011	23/08/2011

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1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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