(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 767 670 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
20.08.2014 Bulletin 2014/34

(51) Int Cl.:
***E21B 33/14** (2006.01)* ***E21B 17/00** (2006.01)*

(21) Application number: **13305080.7**

(22) Date of filing: **23.01.2013**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicants:
- **Services Pétroliers Schlumberger**
  75007 Paris (FR)
  Designated Contracting States:
  FR
- **Schlumberger Holdings Limited**
  Tortola (VG)
  Designated Contracting States:
  GB NL
- **Prad Research Development Limited**
  Tortola (VG)
  Designated Contracting States:
  AT BE CH CY EE ES FI HR IS LI LU LV MC MK MT PT SE SM
- **Schlumberger Technology B.V.**
  2514 JG The Hague (NL)
  Designated Contracting States:
  BG CZ DE DK GR HU IE IT LT NO PL RO SI SK TR

(72) Inventors:
- **James, Simon**
  92142 clamart (FR)
- **Chougnet-Sirapian, Alice**
  92142 Clamart Cedex (FR)

(74) Representative: **Vandermolen, Mathieu**
Etudes & Productions Schlumberger
IP Department
1, rue Henri Becquerel
B.P. 202
92142 Clamart (FR)

(54) Well completion methods

(57) Methods for improving the bonding of a cement sheath (12) to a tubular body (11) in a subterranean well involve anchoring elements (10) mounted on the outside surface of the tubular body-in the annular space between the tubular body and the borehole wall. The cement contains an expansive agent that causes the cement to expand after it sets. The anchoring elements are mounted such that an angle exists between the elements and the tubular-body surface, thereby providing resistance to cement sheath movement away from the tubular-body surface.

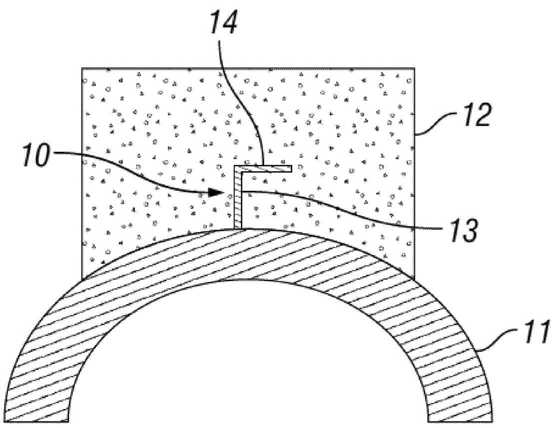

Figure 5

EP 2 767 670 A1

Description

BACKGROUND

[0001] The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

[0002] This disclosure relates to methods for cementing subterranean wells.

[0003] During the construction of subterranean wells, it is common, during and after drilling, to place a tubular body in the wellbore. The tubular body may comprise drillpipe, casing, liner, coiled tubing or combinations thereof. The purpose of the tubular body is to act as a conduit through which desirable fluids from the well may travel and be collected. The tubular body is normally secured in the well by a cement sheath. The cement sheath provides mechanical support and hydraulic isolation between the zones or layers that the well penetrates. The latter function is important because it prevents hydraulic communication between zones that may result in contamination. For example, the cement sheath blocks fluids from oil or gas zones from entering the water table and polluting drinking water. In addition, to optimize a well's production efficiency, it may be desirable to isolate, for example, a gas-producing zone from an oil-producing zone.

[0004] The cement sheath achieves hydraulic isolation because of its low permeability. In addition, intimate bonding between the cement sheath and both the tubular body and borehole is necessary to prevent leaks. Persons skilled in the art know that there are various conditions and events in a wellbore that may interfere with the goal of achieving hydraulic isolation. Such conditions and events include temperature and pressure fluctuations, hydrostatic pressure changes inside casing, mechanical disturbances such as perforating, hydraulic fracturing and seismic movements, and the presence of formation fluids that may be corrosive to the cement sheath, the casing or both.

[0005] Persons skilled in the art also know that, when there is a pressure drop inside cemented casing, the casing diameter may decrease and move away from the cement sheath. As a result, a microannulus may form, providing a fluid-flow path between two subterranean zones or between a subterranean zone and the surface. One method for preventing or sealing a microannulus is to use cement slurries that contain an expanding agent. However, the use of expanding agents is usually limited to wellbore environments in which the Young's modulus of the cement sheath is lower than that of the formation. If the Young's modulus of the cement sheath is higher than that of the formation, the cement sheath will preferentially expand into the formation and away from the casing, thereby increasing the size of the microannulus. In many cases this problem may be overcome by using cement systems that are designed to have low Young's moduli. However, in extreme cases, it is not practical to design cement systems with sufficiently low Young's moduli because strength would be compromised.

SUMMARY

[0006] Embodiments allow improvements by providing well casings that minimize or prevent the expansion of the cement sheath away from the casings.

[0007] In an aspect, embodiments relate to apparatuses for improving bonding of a cement sheath in an annulus of a subterranean well having a borehole wall. The apparatus comprises a tubular body and at least one anchoring element. The anchoring element comprises a stem and a hook. The stem of the anchoring element protrudes from the outer surface of the tubular body by at least 2 mm, but does not protrude farther than about 0.5 times the width of the annulus. The hook is attached to a portion of the stem that is distal to the tubular body, such that the hook and the stem are not collinear.

[0008] In a further aspect, embodiments relate to methods for improving bonding of a cement sheath in an annulus of a subterranean well having a borehole wall. At least one apparatus comprising a tubular body and at least one anchoring element is installed in the wellbore. The element comprises a stem and a hook. The stem protrudes from the outer surface of the tubular body by at least 2 mm, but does not protrude farther than about 0.5 times the width of the annulus. The hook is attached to a portion of the stem that is distal to the tubular body, such that the hook and the stem are not collinear. A cement slurry is prepared that comprises at least one expansive agent. The slurry is placed in the annular space between the outer surface of the tubular body and the borehole wall such that the slurry surrounds the anchoring elements. The slurry is then allowed to set and expand.

[0009] In yet a further aspect, embodiments relate to methods for cementing a subterranean wellbore having a borehole wall. At least one apparatus comprising a tubular body and at least one anchoring element is installed in the wellbore. The element comprises a stem and a hook. The stem protrudes from the outer surface of the tubular body by at least 2 mm, but does not protrude farther than about 0.5 times the width of the annulus. The hook is attached to the portion of the stem that is distal to the tubular body, such that the hook and the stem are not collinear. A cement slurry is prepared that comprises at least one expansive agent. The slurry is placed in the annular space between the outer surface of the tubular body and the borehole wall such that the slurry surrounds the anchoring elements. The slurry is then allowed to set and expand. The tubular body may be casing, liner or coiled tubing or a combination thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 illustrates the formation of a microannulus between a casing string and the cement sheath, resulting from a hydrostatic pressure drop inside the casing string.

[0011] Figure 2 is a graph that illustrates how the Young's modulus of the formation affects the size of a microannulus when an expanding cement system is present.

[0012] Figure 3 illustrates the formation of a microannulus between the cement sheath and the formation, arising from a situation during which a non-expanding cement sheath does not separate from the casing string.

[0013] Figure 4 illustrates the same scenario as Fig. 3 when an expanding cement sheath is present. Microannulus formation does not occur.

[0014] Figure 5 illustrates an embodiment of an anchoring element mounted on the casing string, preventing separation of the cement sheath from the casing string.

[0015] Figure 6 illustrates an embodiment of how anchoring elements may be arranged around the circumference of the casing string.

[0016] Figures 7A-7E illustrate several embodiments of anchoring element shapes. The common theme is that the elements protrude in a manner such that the stem is approximately perpendicular to the casing surface.

[0017] Figure 8A illustrates the orientation of the flow direction at an angle alpha to the plane of the anchoring element. Figure 8B illustrates the orientation of an anchoring element in a well with respect to cement-slurry flow.

[0018] Figure 9 illustrates the orientation of an anchoring element at an angle theta to the flow direction.

DETAILED DESCRIPTION

[0019] The disclosure may be described in terms of treatment of vertical wells, but is equally applicable to wells of any orientation. The disclosure may be described for hydrocarbon production wells, but it is to be understood that the disclosure may be used for wells for production of other fluids, such as water or carbon dioxide, or, for example, for injection or storage wells. It should also be understood that throughout this specification, when a concentration or amount range is described as being useful, or suitable, or the like, it is intended that any and every concentration or amount within the range, including the end points, is to be considered as having been stated. Furthermore, each numerical value should be read once as modified by the term "about" (unless already expressly so modified) and then read again as not to be so modified unless otherwise stated in context. For example, "a range of from 1 to 10" is to be read as indicating each and every possible number along the continuum between about 1 and about 10. In other words, when a certain range is expressed, even if only a few specific data points are explicitly identified or referred to within the range, or even when no data points are referred to within the range, it is to be understood that the inventors appreciate and understand that any and all data points within the range are to be considered to have been specified, and that the inventors have possession of the entire range and all points within the range.

[0020] As discussed earlier, a microannulus may form if the hydrostatic pressure inside the casing falls. An example of this situation is the replacement of a drilling fluid inside casing by a low-density completion fluid. The casing may shrink away from the cement, giving rise to a microannulus. This scenario is illustrated in Fig. 1. The casing **1** is filled with a fluid **2**. When the fluid density falls, the casing shrinks away from the cement sheath **3**, forming a microannulus **4**. The cement sheath may remain bonded to the formation **5**.

[0021] A potential solution to the microannulus problem is to include an expanding agent in the cement system. However, the ability of such a cement system to close a microannulus may depend on the mechanical properties of the cement sheath and the formation. One may use the CemSTRESS™ wellbore modeling application, available from Schlumberger, to perform an analysis of these relationships. The physics of the model is described in the following publication: Thiercelin MJ et al.: "Cement Design Based on Cement Mechanical Response," paper SPE 52890 (1998*).* The software may be used to determine the optimal mechanical properties of the set cement and the necessary amount of cement-sheath expansion. Ultimately, a cement system may be designed that meets the requirements specified by the software.

[0022] A CemSTRESS™ simulation, illustrated in Fig. 2, assumes that the Young's modulus of the formation is 7000 MPa and that there is a 38-μm microannulus between the cement sheath and the casing. The well geometry consists of a 17.8-cm (7-in) casing in an 21.6-cm (8.5-in.) open hole. When the Young's modulus of the cement sheath exceeds that of the formation, the presence of an expanding cement exacerbates the microannulus problem (i.e., the microannulus becomes wider). To overcome this problem, another method may be required to ensure that the cement sheath remains attached to the casing.

[0023] Figure 3 illustrates what may happen when a conventional non-expansive cement sheath is made to remain attached to the casing. The microannulus **4** may form at the interface between the cement sheath **3** and the formation **5**. This scenario is also undesirable because the microannulus may allow the passage of formation fluids between subterranean zones or to the surface. Use of an expanding cement may minimize or prevent the formation of a microannulus at the cement-formation interface (Fig. 4).

[0024] There are numerous ways by which an expanding cement may be provided. A thorough overview of expanding cements is presented in the following publications. Nelson EB, Drochon B, Michaux M and Griffin TJ: "Special Cement Systems," in Nelson EB and Guillot D (eds.): Well Cementing-2rd Edition. Houston: Schlumberger (2006): 233-268; and patent application EP

2457974 A1. Any of the expanding cement systems described in the literature may be compatible with the methods disclosed in the present application.

[0025] Applicant has determined methods by which the cement sheath may be anchored to well tubulars, which may comprise casing, liner, coiled tubing or a combination thereof. The tubulars may be fabricated from steel, titanium, aluminum, a composite material or plastic. The anchoring mechanism may have the following characteristics.

- Sufficient length to allow a cement slurry to flow and displace drilling fluid between the anchoring elements and the casing, but not too long to negatively affect the running of casing into the borehole.
- Sufficient rigidity to survive placement in the borehole and not be deformed by cement expansion. Applicant has determined that elements at least 1 mm thick (if fabricated from steel) may have sufficient rigidity.
- Distributed evenly around the casing circumference and along the length where anchoring is required (hence a helicoidal arrangement).
- Designed to allow the flow of spacer fluid and cement to displace drilling fluid - oriented perpendicular to, or at low angle to the flow direction or sufficiently thin to prevent entrapment of the drilling fluid.
- May be directly welded to the casing or attached by rigid clamps, or the tubular body may be machined such that grooves are created that effectively create protrusions.

[0026] It may not be necessary for the anchoring elements to be placed on every joint of casing. The anchoring elements may be confined to key zonal-isolation areas along the casing string, for example along regions where the formation has a low Young's modulus. The anchoring elements may also be part of a special joint that is run as part of the casing string. The casing or special joint may also include centralizers to help protect the anchoring elements during installation in the well.

[0027] One anchoring mechanism is illustrated in Fig. 5. An anchoring element **10** is attached to casing **11** and protrudes into the cement sheath **12**. The length of the anchor stem **13** may be at least 2 mm to allow fluids to flow freely around the element. However, the length of the element may be less than or equal to 0.5 times the width of the annulus between the casing and the formation. For example, in the annulus between a 7-in. (178-mm) casing string and an 8.5-in. (216-mm) open hole (with zero standoff between the casing and the formation), the length of the anchoring element may be less than 9.5 mm. At the end of the anchor stem is a hook **14**.

[0028] An example of a possible distribution of anchoring elements around a casing string is shown in Fig. 6. The anchoring elements **20** may be arranged on the casing **21** in a helical pattern. The anchoring elements continue in the same pattern along the back side of the casing (not shown). Ideally, the anchoring elements may be spaced at a minimum of 60° phasing around the casing (assuming a 7-in. casing) In Fig. 6, the arrow **22** indicates the circumferential distance between the centers of the anchoring elements. For a 7-in. casing and 60° phasing the distance would be 93 mm. Larger casing diameters may require a minimum phasing of 30° with the aim of maintaining the circumferential spacing below about 100 mm. The vertical spacing of the anchoring elements, indicated by arrow **23**, is ideally between 100 mm and 200 mm independent of casing diameter.

[0029] The shape of the anchoring elements may be such that they feature an angle between the stem **13** and the hook (hereinafter called the hook angle), thus providing mechanical resistance to set cement attempting to separate from the casing. The shapes may comprise those illustrated in Figs. 7A-7E. Each figure shows an anchoring element **13** mounted on casing **11**. The hook angle **15** may be $\geq 0°$ to allow good mud removal in all orientations and $<170°$ to hold the cement in place.

[0030] In some instances the hook angle **15** may be less than about 90°, but in this case the anchoring element should be oriented with respect to the flow direction to ensure that cement surrounds the anchoring element.

[0031] The stem may have a circular cross section with a diameter between 1 mm and 20 mm, between 1 mm and 10 mm or between 1 mm and 5 mm. The stem may have a rectilinear cross section with the largest dimension between 1 mm and 20 mm, between 1 mm and 10 mm or between 1 mm and 5 mm. In these cases the orientation of the hook element in relation to the cement slurry flow direction is not important, provided that the hook angle is not less than about 90°.

[0032] If the hook angle **15** is less than about 90° (Fig. 8A) the anchoring element may be oriented so that cement-slurry flow can easily remove the drilling fluid from the area surrounding the anchoring element. In this case the anchoring element should be oriented such that cement slurry flows past the element at an angle alpha (α) less than about $\pm 45°$ or greater than $\pm 135°$. As shown in Fig 8A, if one envisions fluid flowing vertically out of the page toward the reader, the angle α is either 0° or 180°. If one envisions fluid flowing horizontally along the page in a direction perpendicular to the larger dimension of stem **13,** the angle α is either -90° or +90°. The orientation of an anchoring element, and it's angle α with respect to the direction of cement slurry flow in a well (indicated by the arrows), is shown in Fig. 8B.

[0033] The stem may be made of sheet like material where the rectangular cross section has a largest dimension between 1 mm and 20 mm, between 1 mm and 10 mm or between 1 mm and 5 mm.. As shown in Fig. 9, in this case the orientation of the larger dimension of the stem with respect to the flow **90** has to be controlled to allow optimal mud removal. The angle theta (θ) as shown in Fig. 9 should ideally be less than about $\pm 45°$ or greater than $\pm 135°$. For reference, if the stem of the anchoring device is parallel to the flow **90**, the angle theta (θ) is 0°

or 180°.

[0034] In an aspect, embodiments relate to apparatuses for improving bonding of a cement sheath in an annulus of a subterrenean well having a borehole wall. The apparatus comprises a tubular body and at least one anchoring element. The anchoring element comprises a stem and a hook. The stem of the anchoring element protrudes from the outer surface of the tubular body by at least 2 mm, but does not protrude farther than about 0.5 times the width of the annulus. The hook is attached to a portion of the stem that is distal to the tubular body, such that the hook and the stem are not collinear.

[0035] In a further aspect, embodiments relate to methods for improving bonding of a cement sheath in an annulus of a subterranean well having a borehole wall. At least one apparatus comprising a tubular body and at least one anchoring element is installed in the wellbore. The element comprises a stem and a hook. The stem protrudes from the outer surface of the tubular body by at least 2 mm, but does not protrude farther than about 0.5 times the width of the annulus. The hook is attached to a portion of the stem that is distal to the tubular body, such that the hook and the stem are not collinear. A cement slurry is prepared that comprises at least one expansive agent. The slurry is placed in the annular space between the outer surface of the tubular body and the borehole wall such that the slurry surrounds the anchoring elements. The slurry is then allowed to set and expand.

[0036] In yet a further aspect, embodiments relate to methods for cementing a subterranean wellbore having a borehole wall. At least one apparatus comprising a tubular body and at least one anchoring element is installed in the wellbore. The element comprises a stem and a hook. The stem protrudes from the outer surface of the tubular body by at least 2 mm, but does not protrude farther than about 0.5 times the width of the annulus. The hook is attached to a portion of the stem that is distal to the tubular body, such that the hook and the stem are not collinear. A cement slurry is prepared that comprises at least one expansive agent. The slurry is placed in the annular space between the outer surface of the tubular body and the borehole wall such that the slurry surrounds the anchoring elements. The slurry is then allowed to set and expand. The tubular body may be casing, liner or coiled tubing or a combination thereof.

[0037] For all aspects the anchoring elements may be arranged in a helical pattern around the outer surface of the tubular body.

[0038] For all aspects, the cement slurry may comprise an inorganic cement comprising Portland cement, calcium aluminate cement, fly ash, blast furnace slag, lime/silica blends, cement kiln dust, magnesium oxychloride, chemically bonded phosphate ceramics, zeolites, geopolymers and combinations thereof. Organic cement systems comprising epoxy resins, phenolic resins, furan resins and the like are also envisioned.

[0039] For all aspects, the expansive agent in the cement slurry may comprise sodium chloride, calcium sulfate, aluminum sulfate, iron (II) sulfate, magnesium oxide, calcium oxide, aluminum metal, zinc metal, magnesium metal, swellable particles in emulsified oils or combinations thereof.

[0040] Although various embodiments have been described with respect to enabling disclosures, it is to be understood that the preceding information is not limited to the disclosed embodiments. Variations and modifications that would occur to one of skill in the art upon reading the specification are also within the scope of the disclosure, which is defined in the appended claims.

Claims

1. An apparatus for improving bonding of a cement sheath in an annulus of a subterranean well having a borehole wall, comprising:

   (i) a tubular body; and
   (ii) at least one anchoring element, the element comprising a stem and a hook; wherein the stem protrudes from the outer surface of the tubular body by at least 2mm, but does not protrude farther than about 0.5 times the width of the annulus; and the hook is attached to a portion of the stem that is distal to the tubular body, such that the hook and the stem are not collinear.

2. The apparatus of claim 1, wherein the tubular body is casing, liner or coiled tubing or a combination thereof.

3. The apparatus of claim 1 or 2, wherein the stem has a circular cross-sectional diameter of a rectilinear cross-sectional length, and the length or the diameter does not exceed 20 mm.

4. The apparatus of any one of claims 1-3, further comprising at least one weld that attaches the apparatus to the tubular body.

5. The apparatus of any one of claims 1-4, further comprising at least one clamp that attaches the apparatus to the tubular body.

6. The apparatus of any one of claims 1-5, wherein the apparatus is fabricated from steel, titanium, aluminum, a composite material, a plastic or a combination thereof.

7. The apparatus of any one of claims 1-6, wherein the apparatus is fabricated from steel, and the cross sectional thickness of the stem is between 1 mm and 20 mm.

8. A method for improving bonding of a cement sheath

in an annulus of a subterranean well having a borehole wall, comprising:

(i) installing in the wellbore at least one apparatus comprising a tubular body and at least one anchoring element, the element comprising a stem and a hook, wherein the stem protrudes from the outer surface of the tubular body by at least 2mm, but does not protrude farther than about 0.5 times the width of the annulus; and the hook is attached to a portion of the stem that is distal to the tubular body, such that the hook and the stem are not collinear;
(ii) preparing a cement slurry comprising at least one expansive agent;
(iii) placing the cement slurry in an annular space between the outer surface of the tubular body and the borehole wall, such that the slurry flows along the outer surface of the tubular body and surrounds the anchoring elements; and
(iv) allowing the cement slurry to set and expand.

9. The method of claim 8, wherein the tubular body is casing, liner or coiled tubing or a combination thereof.

10. The method of claim 8 or 9, wherein the stem protrudes from the tubular body surface by at least 2 mm, but does not protrude farther than 0.5 times the width of the annulus.

11. The method of any one of claims 8-10, wherein the anchoring elements are arranged in a helicoidal pattern around the outer surface of the tubular body.

12. The method of any one of claims 8-11, wherein the stem has a circular cross-sectional diameter or a rectilinear cross-sectional length, and the length or the diameter does not exceed 20 mm.

13. The method if any one of claims 8-12, wherein the stem comprises a sheet-like material, and an angle θ between the larger dimension of the stem and the direction of slurry flow along the outer surface of the tubular body is less than about $\pm 45°$ or greater than $\pm 135°$.

14. The method of any one of claim 8-13, wherein the cement comprises Portland cement, calcium aluminate cement, fly ash, blast furnace slag, lime/silica blends, cement kiln dust, magnesium oxychloride, chemically bonded phosphate ceramics, zeolites, geopolymers, and combinations thereof.

15. The method of any one of claims 8-14, wherein the expansive agent comprises sodium chloride, calcium sulfate, aluminum sulfate, iron (II) sulfate, magnesium oxide, calcium oxide, aluminum metal, zinc metal, magnesium metal, swellable particles in emulsified oils or combinations thereof.

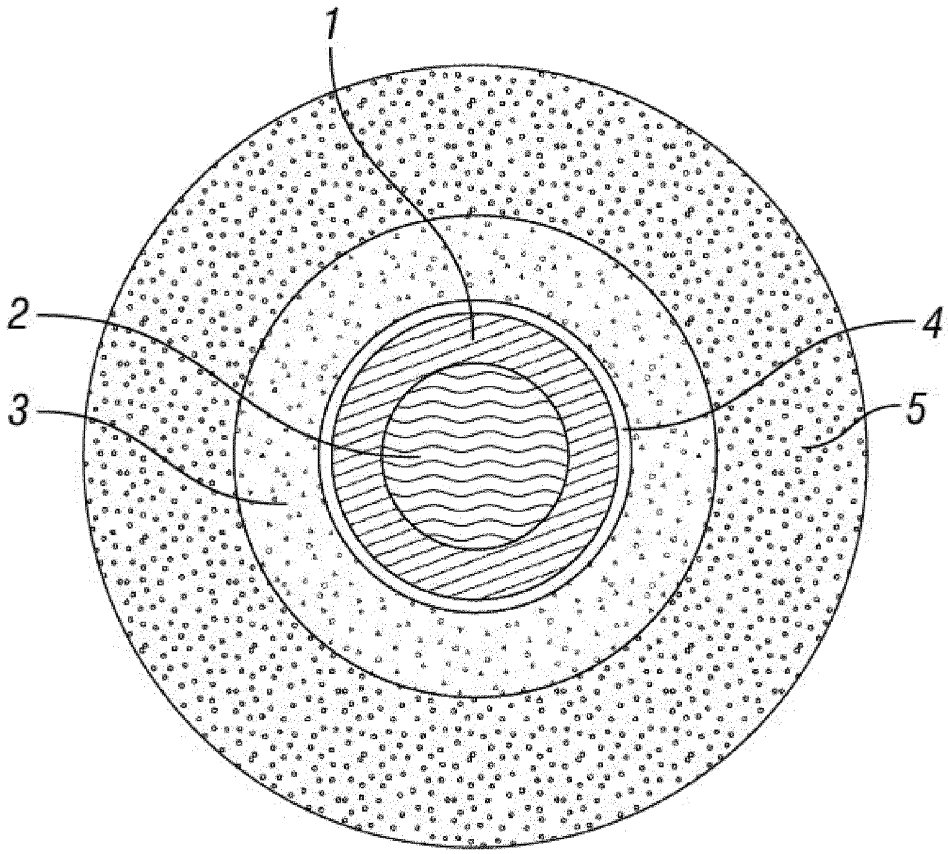

Figure 1

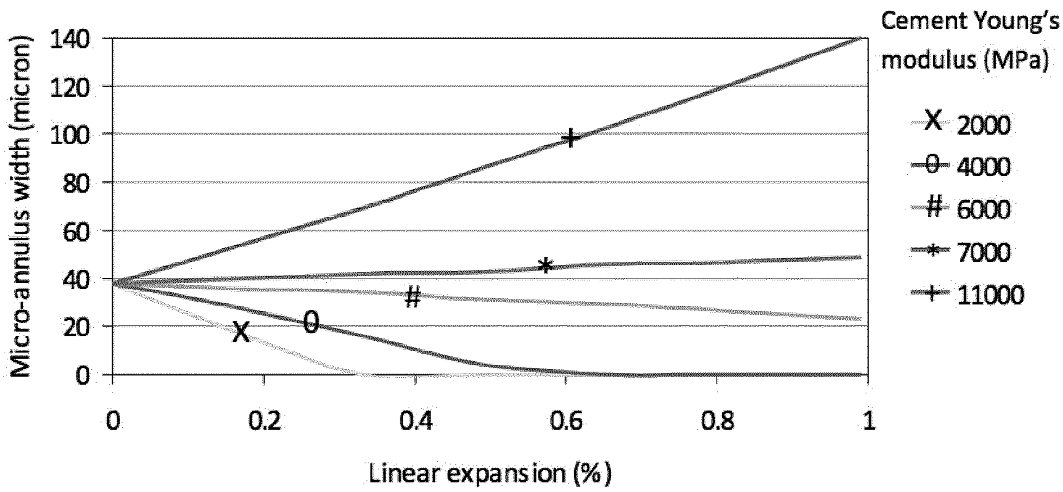
Micro-annulus width (micron)
140
120
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
Linear expansion (%)
Cement Young's modulus (MPa)
X 2000
0 4000
6000
* 7000
+ 11000

Figure 2

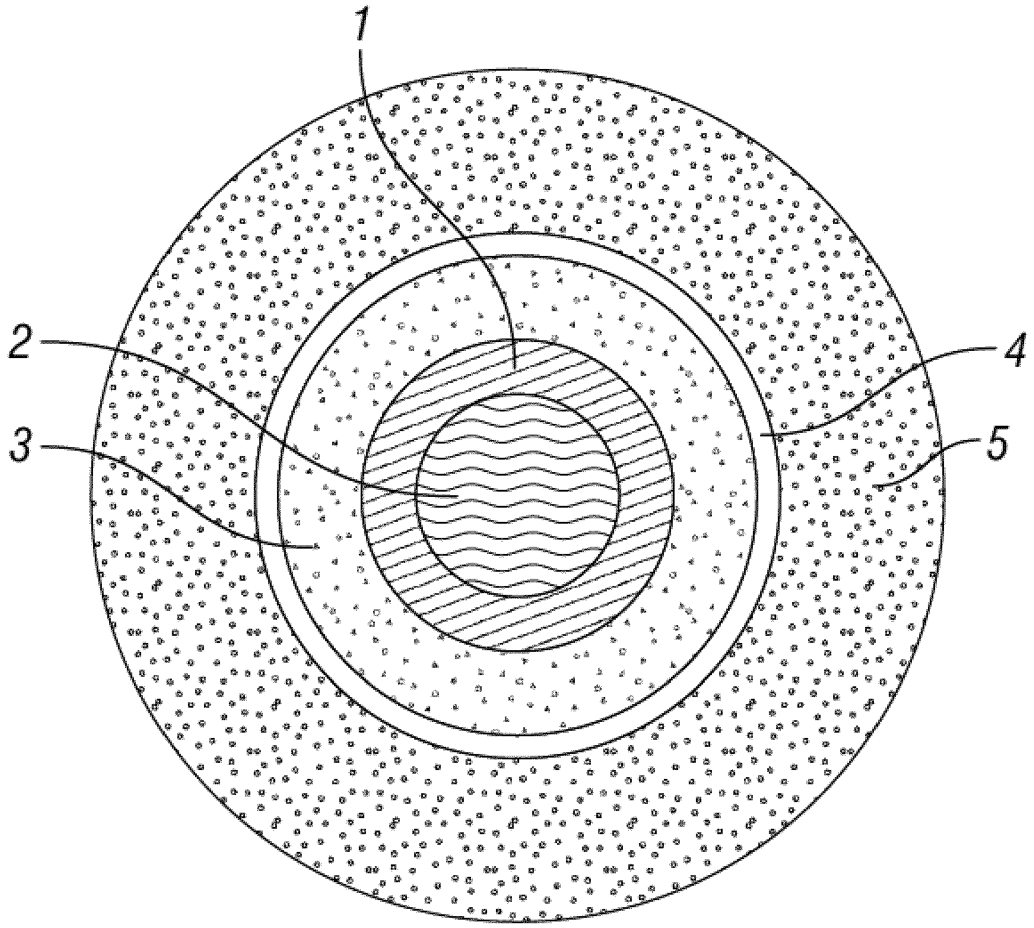

Figure 3

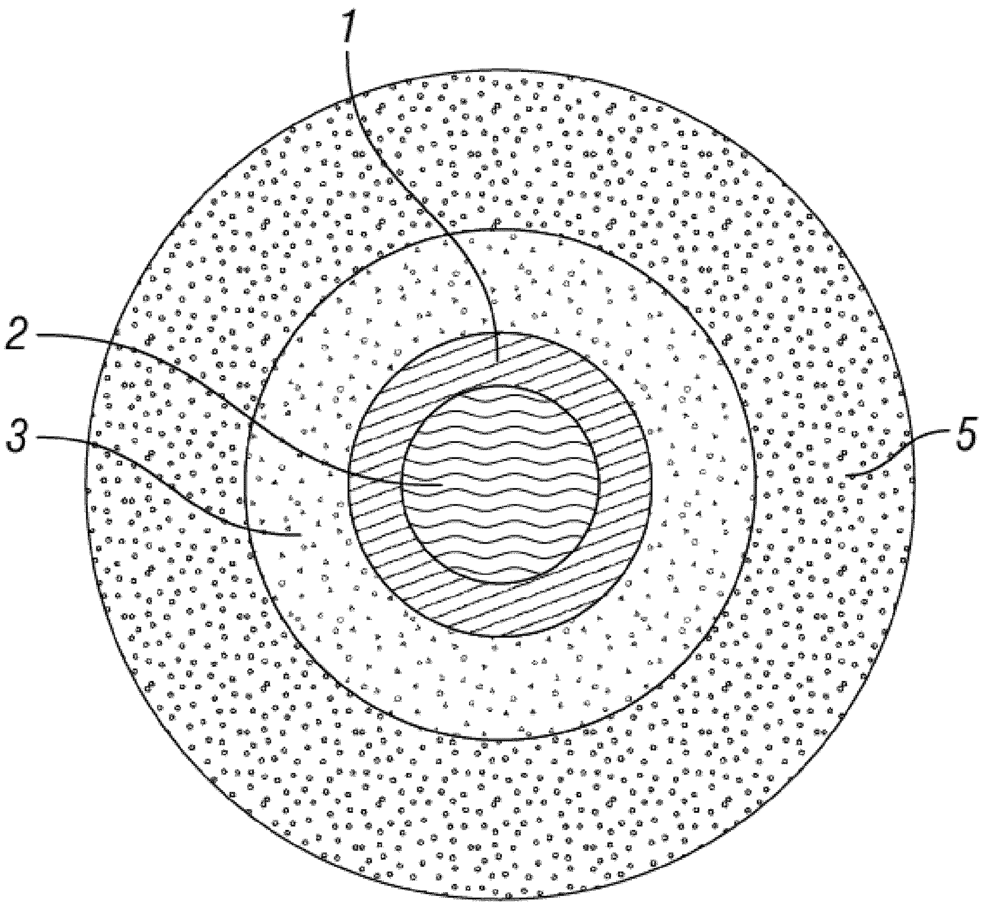

Figure 4

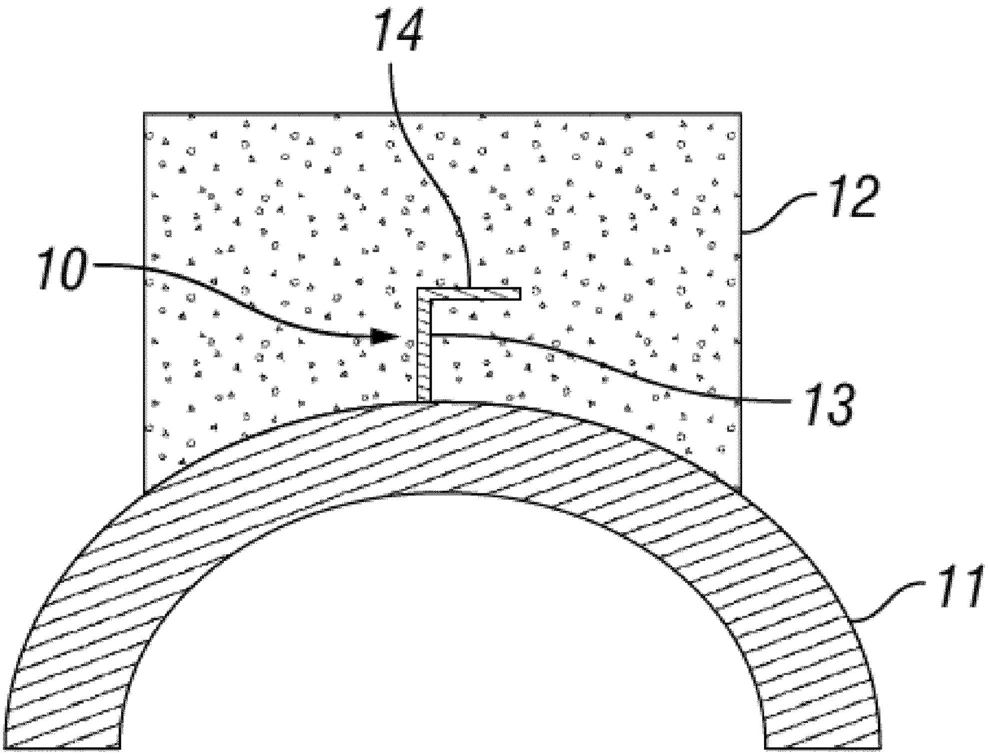

Figure 5

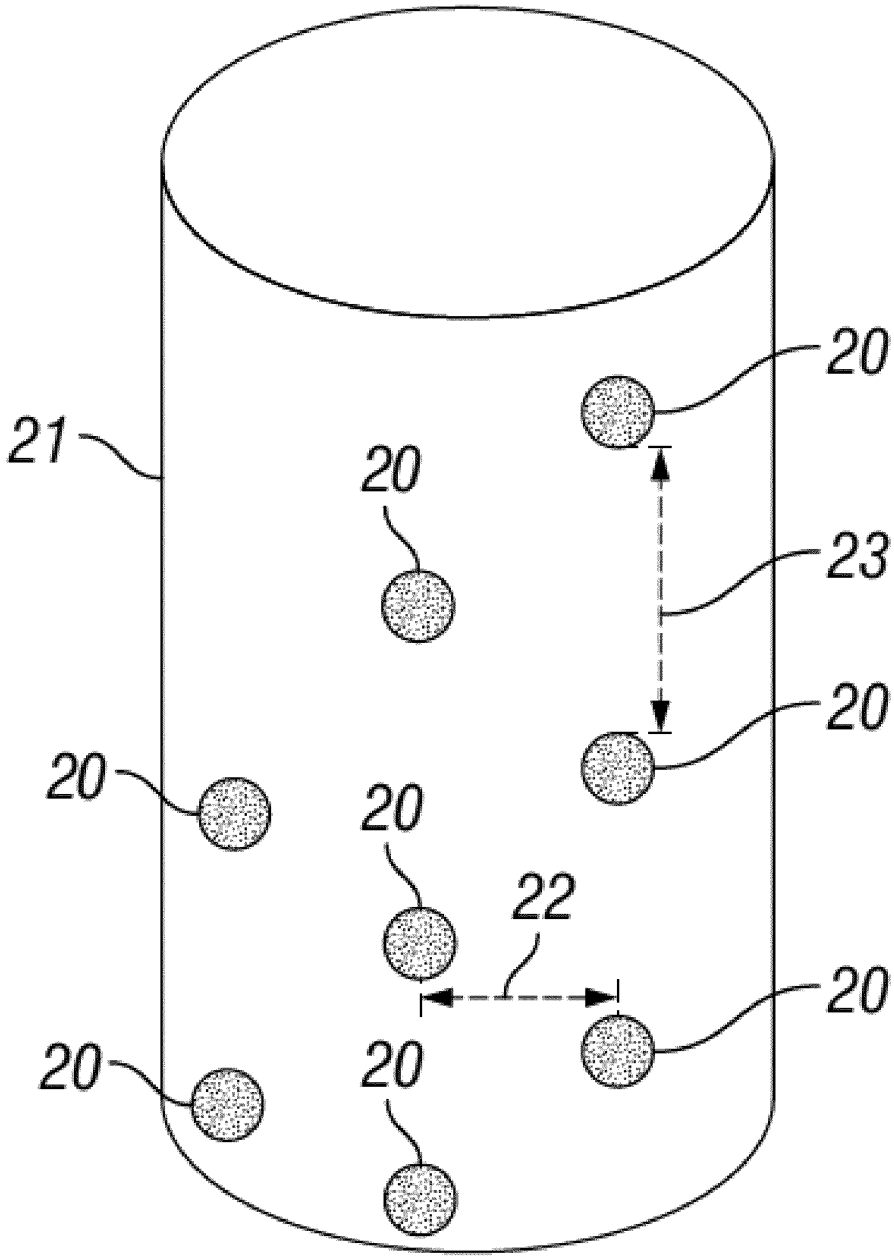

Figure 6

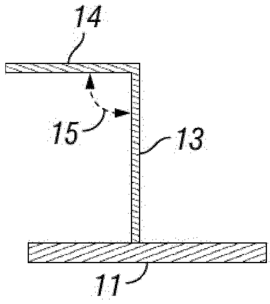

Figure 7A

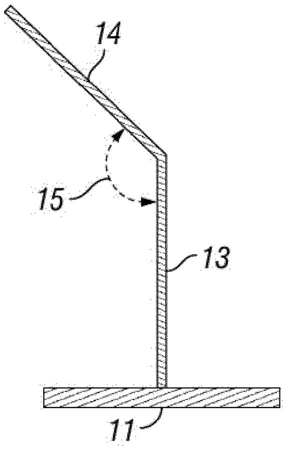

Figure 7B

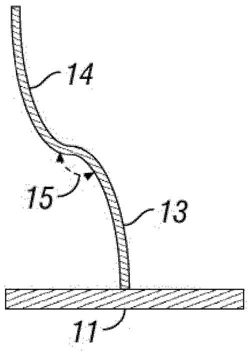

Figure 7C

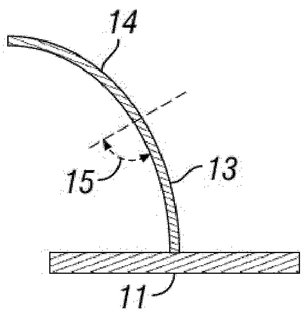

Figure 7D

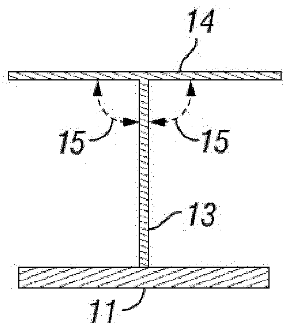

Figure 7E

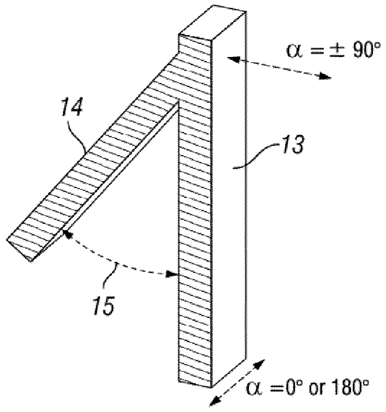

Figure 8A

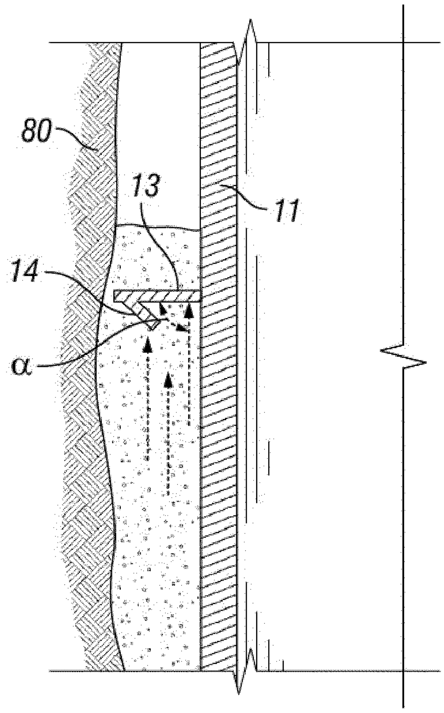

Figure 8B

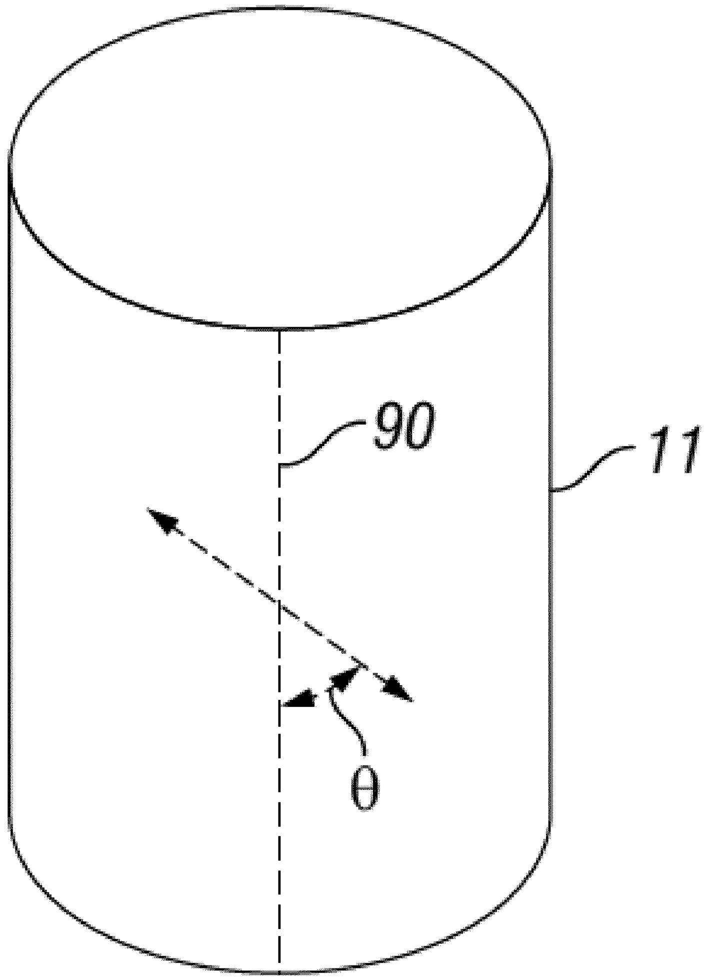

Figure 9

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 30 5080

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 493 372 A (RADD FRED J [US] ET AL) 15 January 1985 (1985-01-15) * column 1, line 39 - line 51; figures 1-4 * * column 2, line 20 - line 34 * * column 2, line 37 - line 52 * * column 3, line 44 - line 52 * * column 4, line 4 - line 18 * * column 5, line 8 - column 6, line 15 * -----	1-15	INV. E21B33/14 E21B17/00
X	US 4 495 997 A (SCOTT JAMES B [US] ET AL) 29 January 1985 (1985-01-29) * column 2, line 37 - line 58; figures 1,2,5 * * column 5, line 40 - line 47 * -----	1-15	
X	US 4 178 110 A (COBBS JAMES H [US]) 11 December 1979 (1979-12-11) * figures 2,3,5-7 * -----	1-3,6	
X	US 4 070 832 A (GROSCH GOTTLIEB W) 31 January 1978 (1978-01-31) * figures 1-9 * -----	1-4,6,7	TECHNICAL FIELDS SEARCHED (IPC) E21B
X	US 4 241 789 A (GROSCH GOTTLIEB W [US]) 30 December 1980 (1980-12-30) * figures 1-5 * -----	1-4,6	
A	US 2 374 317 A (WRIGHT KENNETH A) 24 April 1945 (1945-04-24) * page 3, column 2, line 49 - line 56; figures 1-4 * -----	1-15	
A	EP 0 197 609 A2 (SHELL INT RESEARCH [NL]) 15 October 1986 (1986-10-15) * claims 1,5; figure 1 * ----- -/--	1-15	

1

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 June 2013	Dantinne, Patrick

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 30 5080

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	EP 2 457 974 A1 (SCHLUMBERGER SERVICES PETROL [FR]; SCHLUMBERGER TECHNOLOGY BV [NL]; SC) 30 May 2012 (2012-05-30) * abstract * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	17 June 2013	Dantinne, Patrick

EPO FORM 1503 03.82 (P04C01)

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 30 5080

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

17-06-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4493372 A	15-01-1985	NONE	
US 4495997 A	29-01-1985	CA 1210318 A1	26-08-1986
		US 4495997 A	29-01-1985
US 4178110 A	11-12-1979	NONE	
US 4070832 A	31-01-1978	NONE	
US 4241789 A	30-12-1980	NONE	
US 2374317 A	24-04-1945	NONE	
EP 0197609 A2	15-10-1986	AU 573435 B2	09-06-1988
		AU 5578686 A	16-10-1986
		CA 1245976 A1	06-12-1988
		DE 3683946 D1	02-04-1992
		DK 160086 A	12-10-1986
		EP 0197609 A2	15-10-1986
		MX 167484 B	25-03-1993
		NO 861379 A	13-10-1986
		US 4716965 A	05-01-1988
EP 2457974 A1	30-05-2012	NONE	

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 2457974 A1 **[0024]**

Non-patent literature cited in the description

- **THIERCELIN MJ et al.** Cement Design Based on Cement Mechanical Response. *paper SPE 52890,* 1998 **[0021]**
- **NELSON EB ; DROCHON B ; MICHAUX M ; GRIFFIN TJ:.** Special Cement Systems. 2006, 233-268 **[0024]**