Title: METHOD AND DEVICE FOR DETERMINING TEST PRESSURE IN A WELL

Abstract: A method for determining a test load in a well (1) in the ground (2) in which at least a cemented casing (14, 16) is placed, the method including: - arranging a pressure gauge (34) within or outside the casing (14, 16), the pressure gauge (34) being arranged to measure the pressure on the outside of the casing (14, 16) or the differential pressure between the inside and the outside of the casing (14, 16); - reading the measured values and determining the pressure on the outside of the casing (14, 16), and - determining the test pressure on the basis of the pressure capacity of the casing (14, 16) or other well components, the internal pressure and the measured external pressure.
METHOD AND DEVICE FOR DETERMINING TEST PRESSURE IN A WELL

This invention relates to a method for determining a test pressure in a well in the ground. More particularly, it relates to a method for determining a test pressure in a well in the ground in which at least a cemented casing is placed. The invention also includes a device for practising the method.

A well in the ground, typically an oil, gas or injection well, is often formed with a number of casings arranged within each other. The casing that has the largest diameter extends somewhat down into the ground. The next casing, which has a somewhat smaller diameter, extends somewhat further down the well, and so on. The number of casings in the well may vary according to the well depth and geological conditions.

The inner casing is often called production casing and typically extends from a reservoir up to a wellhead. The wellhead includes safety valves. A production tubing which has been sealed externally by means of a packer relatively deep in the well is arranged in the production casing.

The casings are cemented to the surrounding formation. However, it is common that only the lower portion of the inner casing is cemented. The area above the cement and up to the surface is filled with drilling mud of a particular specific
As the cement is porous, it is assumed that water pressure is prevalent around the casing in the cemented portion. Considerable uncertainty attaches to the condition of the drilling mud as it is assumed that the solid particles of the drilling fluid will settle over time, whereby the specific gravity of the remaining drilling mud is assumed to approach the specific gravity of the water.

The regulations in force require a well to be pressure-tested at the expected pressure. It is evident that uncertainty attached to the external pressure around the casings affects the choice of test pressure to a considerable degree, the test pressure not being chosen to be so high that the casing or other well equipment will be damaged. Thereby, it may happen that during operation the well is subjected to pressures higher than the test pressure.

In the late stage of extraction from a field, it may happen that a production well is made into an injection well. This will subject the well equipment to considerably higher strains because the injection pressure required is relatively high. Before the well is used for this purpose, it is necessary to determine whether the well can take the conversion. The assumptions mentioned concerning external pressure bring considerable uncertainty into the calculations.

The invention has for its object to remedy or reduce at least one of the drawbacks of the prior art.

The object is achieved in accordance with the invention through the features which are specified in the description below and in the claims that follow.

A method is provided for determining a test load in a well in gravity.
the ground in which at least a cemented casing is placed, the method including:
- arranging a pressure gauge in the casing, the pressure gauge being arranged to measure the pressure on the outside of the casing, or the differential pressure between the inside and the outside of the casing;
- reading the measured values and determining the pressure on the outside of the casing; and
- determining the pressure load on the basis of the pressure capacity of the casing or other well components, the internal pressure and the measured external pressure.

The pressure on the inside of the casing is known. The load on the casing may thereby be determined with considerably greater certainty than when the prior art is used.

The method may include arranging a number of pressure gauges spaced along the casing. This makes it possible to determine the test pressure from the pressure capacity of the weakest portion of the well, the external pressure at this portion then being known.

The method may further include:
- determining the axial load on the casing at the pressure gauge; and
- determining the total 3-D load on the casing.

The method may be practised by means of pressure-measuring equipment in a well in the ground in which at least a cemented casing is placed, and in which the casing is provided with a pressure gauge which is arranged to measure the pressure on the outside of the casing or the differential pressure between the inside and the outside of the casing.

The casing may be provided with several pressure gauges along its longitudinal extent.
The pressure gauges communicate with a reading unit on the surface, the pressure gauges being individually readable.

The pressure gauges may be constituted by strain gauges or semiconductor gauges, for example. They may be installed in, for example, a production tubing, a production casing or other relevant casings and be arranged in the pipe itself or in a component connected to the pipe.

In some wells a measuring chain which is lowered into a second annulus surrounding a production casing may provide useful information about the pressure around the production casing. A measuring chain is provided with a number of pressure gauges along its longitudinal extent.

Uncertainty about the prevalent pore pressure because of pore pressure build-up around the production tubing also leads to uncertainty in relation to the test pressure in the well. This problem, too, is solved by means of the proposed method.

The method and the device in accordance with the invention contribute to a substantially better knowledge about the prevalent pressure conditions in a well and thereby to the choice of a test pressure that reflects the relevant pressures that arise during operation of the well. This may also help to solve the substantial integrity problems, that is to say leaks, which occur in existing wells. The proposed method and device are well suited for application during the construction, overhaul as well as the normal operation of a well in the ground. It is equally usable in wells which have been temporarily or permanently plugged back.

In what follows is described an example of a preferred method and embodiment visualized in the accompanying drawings, in which:
Figure 1 shows a principle drawing of a well which is provided with measuring equipment according to the invention;

Figure 2 shows schematically, on a larger scale, a section through a casing that is provided with a strain gauge;

Figure 3 shows schematically a section through a casing that is provided with a semiconductor gauge; and

Figure 4 shows a graph which illustrates the differential pressure in the well and the uncertainty when test pressures are determined according to the prior art.

In the drawings the reference numeral 1 indicates a well in the ground 2. The ground 2 comprises a formation 4 with a reservoir 6. A conductor casing 8 extends from a wellhead 10 down into the formation 4. A surface casing 12 extends through the conductor casing 8 and somewhat further into the formation 4.

An intermediate casing 14 extends through the surface casing 12 and further into the formation 4, whereas a production casing 16 extends from the wellhead 10 through the intermediate casing 14 and into the reservoir 6.

A production tubing 18 extends through the production casing 16 between the reservoir 6 and the wellhead 10. The production tubing 18 is externally sealed against the production casing 16 by means of a packer 20 at the lower portion of the production casing 16.

The conductor casing 8 and the surface casing 12 are externally cemented to the formation 4 or, respectively, the for-
mation 4 and the conductor casing 8, by means of cement 22.

The intermediate casing 14 is cemented to the formation 4 by means of cement 24 at its lower portion. A first annulus 26 which is above the cement 24 between the intermediate casing 14 and the formation 4 or the surface casing 12 is filled with drilling mud.

Correspondingly, the production casing 16 is cemented to the formation 4 by means of cement 28 at its lower portion. A second annulus 30 which is above the cement 28 between the production casing 16 and the formation 4 or the intermediate casing 14 is filled with drilling mud.

A third annulus 32 surrounding the production tubing 18 above the packer 20 is filled with fluid of a known specific gravity.

A number of pressure gauges 34 are arranged in the pipe wall 36 of the production casing 16, see figures 2 and 3. The pressure gauges 34 communicate with a reading unit 38 via a connection 40. The connection 40 may be formed by an electrical cable or an optical cable, for example.

The uncertainty in the determination of the test pressure can be illustrated by means of an example, see figure 4, in which the differential pressure P is shown along a horizontal axis and the well depth H is shown along a vertical axis. The line 42 shows the differential pressure of the production casing 16 from the test pressure. The line 44 shows the differential pressure if the fluid in the second annulus 30 is drilling mud, and the line 46 shows the differential pressure if the fluid in the annulus 30 is settled drilling mud, the pressure being applied by the water in the drilling mud. The hatched area 48 indicates the uncertainty in the calculations.
The calculation method is known to a person skilled in the art and is therefore not described in any further detail.

The interface between the cement 28 and the second annulus 30 is at a depth of 1700 metres, whereas the packer is at a depth of 2000 metres. Any support from the cement 24, 28 is ignored as it cannot be tested.

The reservoir pressure corresponds to a specific gravity of 1.7 kg/l.

Specific gravities:

- reservoir fluid 0.7 kg/l
- drilling mud in the second annulus 30 1.76 kg/l
- fluid in the third annulus 32 1.15 kg/l
- water in the cement 28 1.03 kg/l

A surface pressure of 196 bars would give a differential pressure of 94.3 bars at the interface between the cement 28 and the second annulus 30, and 97.8 bars at the packer 20.

If the drilling mud in the second annulus has settled and the specific gravity is 1.03 kg/l, is the differential pressure 219.5 bars at the packer?

When the calculation is done by means of measured values from the pressure gauges 34, the uncertainty stemming from the use of the prior art disappears. The pressures on both sides of the production casing 16 and thereby the differential pressure are known and the test pressure can be determined from the pressure capacities of the production casing 16 and other well components not shown.
Patent claims

1. A method for determining a test load in a well (1) in the ground (2) in which at least a cemented casing (14, 16) is placed, the method including:
   - arranging a pressure gauge (34) within or outside the casing (14, 16), the pressure gauge (34) being arranged to measure the pressure on the outside of the casing (14, 16) or the differential pressure between the inside and the outside of the casing (14, 16);
   - reading the measured values and determining the pressure on the outside of the casing (14, 16), characterized in that the method further includes determining the test pressure on the basis of the pressure capacity of the casing (14, 16) or other well components, the internal pressure and the measured external pressure.

2. The method in accordance with claim 1, characterized in that the method includes arranging a number of pressure gauges (34) spaced along the casing (14, 16).

3. The method in accordance with claim 1, characterized in that the method includes:
   - determining the axial load on the casing (14, 16) at the pressure gauge (34); and
   - determining the total 3-D load on the casing (14, 16).
A. CLASSIFICATION OF SUBJECT MATTER

IPC: E21B 47/10 (2006.01), G01M 3/28 (2006.01)

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)

E21B, G01M

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

NO, DK, SE, Fi: Classes as above

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

EPPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search: 23/06/2011

Date of mailing of the international search report: 27/06/2011

Name and mailing address of the ISA/
Nordic Patent Institute
Helgeshoj Alle 81, DK-2630 Taastrup, Denmark
Facsimile No. (+45) 43 50 80 08

Authorized officer
Kalland, Bjørn Inge
Telephone No. (+47) 23 38 74 00
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