Description

The present invention relates to an improved method of and apparatus for the protection of well components from damage due to being exposed to excessive pressure resulting from the downhole environment in which they are to operate.

US-A-4,662,663 discloses the use of a volume compensating material on the interior of a first tubular member which is to have a second tubular member pressure formed into a grooved surface on the interior of the first tubular member at an underwater location. The volume compensating material is utilized to exclude water from the grooves so that it will not create a hydraulic lock preventing proper deformation of the second tubular member into sealing and gripping engagement within the grooves on the interior of the first tubular member. One material suggested for this volume compensating material is a plurality of microspheres held in an epoxy matrix.

This type of material is designed to function to cause the microspheres to rupture upon the application of pressure and allow the entry therein of any trapped liquid and to crush at excessive forming pressures to thereby allow the completion of the pressure forming. Another reference making similar suggestions is US-A-4,593,448.

A recently issued US-A-4,869,535 discloses the use of such volume compensating material in a downhole environment, particularly in an annular chamber into which an annular piston moves responsive to pressure. In this patent the volume compensating material functions to exclude fluids which might prevent the desired movement of the piston and allows such movement by the crushing of the material responsive to the pressure force exerted thereon by the pressured piston.

According to the present invention, a method of protecting well equipment from pressure surges in a downhole location includes the steps of securing a volume compensating material to a portion of the well equipment so that the volume compensating material is exposed to well pressures at the downhole location, the volume compensating material having sufficient resistance to withstand normal head pressures within the downhole location but rupturing responsive to pressures above such normal head pressures, and lowering the well equipment in the well to the downhole location.

The invention also includes apparatus for protecting well equipment from pressure surges in a downhole location, the apparatus comprising a body forming a part of the well equipment and having a surface exposed to well fluids in a downhole location, and an annular ring of volume compensating material positioned on the body surface exposed to well fluids, the volume compensating material having a resistance to sustain normal fluid head pressures at the downhole location and allowing volume changes responsive to abnormal pressures at the downhole location.

The present invention thus relates to an improved method of and apparatus for protecting downhole equipment from damage caused by changes in the environment of the well in which they are positioned, in the downhole location. It involves the use of a volume compensating material which is preselected to resist the normal hydrostatic pressure of the downhole location to which it is exposed, but when conditions at the downhole location change, such as an increase in pressure above the normal hydrostatic pressure which would result from temperature increases of the fluid confined in the annulus from the heating of the liquid by the well fluids flowing thereby from lower depths of the well. Such material functions to allow volume which prevent pressure increases that would damage the downhole equipment. The apparatus includes the use of a preselected volume compensating material in surrounding relation to a well string which is positioned within a well and is surrounded by another string which well fluids contained in the annulus between the two strings. Another form of apparatus is the inclusion of a preselected volume compensating material in the surface of a resilient well string seal between the upper and lower lip seals to protect the resilient seal from being subjected to excessive pressure which could create pressures releasing the metal lip seals or cause the resilient seal to be extruded from its desired sealing position.

The present invention will now be explained with respect to the drawings wherein:

FIGURE 1 is an elevation view of a subsea well illustrating the environment to which the present invention applies.

FIGURE 2 is a sectional view of the well illustrating the improved apparatus of the present invention as applied to a string in the downhole environment illustrated in FIGURE 1.

FIGURE 2A is an enlarged detail sectional view of a portion of the inner string to which the improved apparatus of the present invention has been applied as shown in FIGURE 2.

FIGURE 3 is a sectional view of an improved annulus seal having both upper and lower metal lip seals and an intermediate resilient seal with the invention incorporated therein.

FIGURE 4 is another sectional view of a modified form of the seal shown in FIGURE 3.

As shown in FIGURE 1, a subsea well 10 is illustrated and includes the usual wellhead production equipment 12 with outer wellhead casing 14 extending downward in well 10. Casing string 16 is positioned within wellhead casing 14 and extends downwardly therein as shown. Within.casing string 16, string 18, which is a production string, extends downwardly within casing string 16 and the present inven-

tion is provided in surrounding relationship to either casing string 16 or string 18 to protect them from physical damage as a result of an increase in the pressure conditions in the annulus which conditions are above those pressures normally expected as a result of the head of liquid under which they operate. Such conditions can result from the production of hot production fluids which cause the annulus fluids surrounding the production string 18 to become heated and in the normal subsea production equipment, the added heating of the annulus fluids creates an increase in the pressure in the annulus since such equipment does not have any way in which to vent the annulus short of reworking the wellhead production unit.

In solving this problem of compensating for the increase in pressure in the annulus 20 resulting from the heating, either from the production fluids or other sources in the well, it is preferred to provide a volume compensating material positioned in the annulus having sufficient collapsible volume to prevent any increase of the annulus pressure to a damaging level. It should be noted that excessively high annulus pressures may damage either the interior string 22 or the exterior string 24 or both. As shown in FIGURE 2 and 2A, it is preferred that the volume compensating material be provided on the exterior of the interior string 22 and is applied in half cylindrical sections 26 which are held in surrounding relationship to interior string 22 by bands 28. End bands 30 are positioned around the upper and lower ends of the uppermost and the lowermost half sections to secure the sections in their desired position longitudinally on the section 32 of the interior string 22. Skin 34 is positioned on the exterior of half sections 26 and is provided to protect half sections 26 during the lowering of interior string 22 into position. It should be noted that skin 34 may be a metal sheath or a plastic skin which protects the volume compensating half sections 26 from damage during lowering of string 22. Further skin 34 should be porous or have sufficient openings or pores therein to allow ready access of the annulus fluids to the interior of the volume compensating material. Generally, the preferred volume compensating material for use in the present invention is microspheres in an epoxy matrix with the material being selected to withstand the normally expected annulus pressures to which it will be exposed. The pressure rating of such materials is readily achieved by known methods. It should be understood that any other suitable type of volume compensating material which can be provided with a suitable structure to withstand the normally expected annulus pressures and still have substantial volume reduction responsive to excessive pressure to cause such pressure to be reduced and preventing them from causing damage to either of the strings forming the inner and outer boundaries of the annulus may be provided.

With the volume compensating material half sections 26 positioned as shown in FIGURE 2 and 2A, any substantial increase in the temperature of the fluids in annulus 20 will cause the pressure to increase above the predetermined maximum desired pressure to be contained in annulus 20. With the volume compensating half sections 26 being exposed to the fluids at such pressure the microspheres will start to rupture providing a volume for the fluids from which they had previously been excluded and thus, reduce the pressure within annulus 20 to the level of the preselected maximum desired pressure. Since half sections 26 have the capability of greatly increasing the available volume for the annulus fluids, the bursting of the microspheres due to overpressure will cause a corresponding increase in volume and the consequent reduction of pressure.

Another application of the present invention is to an annulus seal as illustrated in two embodiments shown in FIGURES 3 and 4. Annulus 40 is between the exterior surface of inner tubular member 42 and the interior surface of outer well member 44. Seal assembly 46 is lowered into position in annulus 40. Seal assembly 46 includes seal body 48 having outer diverging lips 50 and 52 with resilient seal 54 between lips 50 and 52 and a suitable inner seal such as seal rings 56, lower setting ring 58 supported from body 48 and movable with respect thereto, upper setting ring 60 which is supported from and movable with respect to body 48 and actuator 62 which can be rotated to cause setting rings 58 and 60 to be moved toward each other to cause lips 50 and 52 to move outward to their set position. Resilient seal 54 is of a suitable resilient material which is impervious to the well fluid encountered in annulus 40. Ring 64 of volume compensating material is positioned in groove 66 in the exterior of resilient seal 54. It is preferred that the material of ring 64 be such that any fluids trapped between lips 50 and 52 after they are set will cause collapse of the material, such as the collapse of microspheres in the preferred materials, to prevent the generation of excessive pressures resulting from a heating of the fluids or from other reasons causing such pressure increase.

A modified form of annulus seal is illustrated in FIGURE 4 wherein seal assembly 70 includes a structure similar to seal assembly 46 including body 71 with external diverging lips 72 and 74 with resilient seal 76 includes upper ring 78 and lower ring 80 between lips 72 and 74. Ring 82 of volume compensating material is positioned in a space between upper ring 78 and lower ring 80. Ring 82 includes a plurality of radial passages 84 communicating from the exterior of ring 78 to axial passages 86. Passages 84 and 86 are provided to ensure that the fluids trapped between lips 72 and 74 have access to the collapsed microspheres when an excessive pressure has been encountered.

The volume compensating material used with the annulus seals is preferred to be the microspheres in an epoxy matrix previously described with reference to cylindrical half sections 26.

Claims

1. A method of protecting well equipment from pressure surges in a downhole location including the steps of securing a volume compensating material (26,64,82) to a portion of the well equipment (22,54,70) so that the volume compensating material is exposed to well pressures at the downhole location, the volume compensating material having sufficient resistance to withstand normal head pressures within the downhole location but rupturing responsive to pressures above such normal head pressures, and lowering the well equipment in the well to the downhole location.

2. A method according to claim 1, including the step of providing a protective, porous surface (34) for protecting the volume compensating material (26) from normal pressure encountered at the downhole location.

3. A method according to claim 1 or claim 2, wherein the volume compensating material (26) is applied to the exterior of a well string (22) prior to its being lowered into the well.

4. A method according to claim 1, wherein the volume compensating material (64) is provided in a recess (66) in the surface of a resilient seal (54).

5. A method according to claim 4, wherein the resilient seal (54) is positioned between an upper lip seal (50) and a lower lip seal (52).

6. An apparatus for protecting well equipment from pressure surges in a downhole location, the apparatus comprising a body forming a part of the well equipment (22,54,70) and having a surface exposed to well fluids in a downhole location, and an annular ring of volume compensating material (26,64,82) positioned on the body surface exposed to well fluids, the volume compensating material having a resistance to sustain normal fluid head pressures at the downhole location and allowing volume changes responsive to pressures higher than such normal fluid head pressures at the downhole location.

7. An apparatus according to claim 6, wherein the volume compensating material consists of microspheres in a matrix of epoxy.

8. An apparatus according to claim 6 or claim 7, wherein the equipment is a well string (22) and the volume compensating material (26) is installed on the exterior of the well string.

9. An apparatus according to claim 6 or claim 7, wherein the equipment is a pair of concentric well strings (22,24) having an annular space (20) therebetween, and the volume compensating material (26) is installed on one of the strings (22) and exposed to the annular space.

10. An apparatus according to claim 6 or claim 7, wherein the equipment is an annular seal (46) having an upper metal seal (50) lip, a lower metal seal lip (52) and an intermediate resilient seal ring (54) with a recess (66) in the exterior surface of the resilient seal ring, and the volume compensating material (64) is installed in the resilient seal recess.

Patentansprüche

1. Verfahren zum Schutz von Bohrausrüstungen vor sprungartigen Druckanstiegen vor Ort innerhalb eines Bohrloches gekennzeichnet durch Befestigung eines volumenausgleichenden Materials (26, 64, 82) an einem Abschnitt der Bohrausrüstung (22, 54, 70), so daß das volumenausgleichende Material Bohrdrücken im Bohrloch ausgesetzt ist, wobei das volumenausgleichende Material genügend Widerstandsvermögen besitzt, um den normalen Spitzendrücken vor Ort im Bohrloch standzuhalten, jedoch in Reaktion auf Drücke oberhalb solcher normalen Spitzendrücke nachgibt, und durch Absenken der Bohrausrüstung vor Ort im Bohrloch absenkt.

2. Verfahren nach Anspruch 1, gekennzeichnet durch das Schaffen einer schützenden, porösen Fläche (34) zum Schutz des volumenausgleichenden Materials (26) vor dem vor Ort im Bohrloch auftretenden normalen Druck.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet**, daß das volumenausgleichende Material (26) an der Außenseite eines Rohrstranges (22) vor seinem Absenken in das Bohrloch angebracht wird.

4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß das volumenausgleichende Material (64) in einer Ausnehmung (66) in der Oberfläche einer elastischen Dichtung (54) angeordnet ist.

5. Verfahren nach Anspruch 4, **dadurch gekenn-**

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The volume compensating material used with the annulus seals is preferred to be the microspheres in an epoxy matrix previously described with reference to cylindrical half sections 26.

Claims

1. A method of protecting well equipment from pressure surges in a downhole location including the steps of securing a volume compensating material (26,64,82) to a portion of the well equipment (22,54,70) so that the volume compensating material is exposed to well pressures at the downhole location, the volume compensating material having sufficient resistance to withstand normal head pressures within the downhole location but rupturing responsive to pressures above such normal head pressures, and lowering the well equipment in the well to the downhole location.

2. A method according to claim 1, including the step of providing a protective, porous surface (34) for protecting the volume compensating material (26) from normal pressure encountered at the downhole location.

3. A method according to claim 1 or claim 2, wherein the volume compensating material (26) is applied to the exterior of a well string (22) prior to its being lowered into the well.

4. A method according to claim 1, wherein the volume compensating material (64) is provided in a recess (66) in the surface of a resilient seal (54).

5. A method according to claim 4, wherein the resilient seal (54) is positioned between an upper lip seal (50) and a lower lip seal (52).

6. An apparatus for protecting well equipment from pressure surges in a downhole location, the apparatus comprising a body forming a part of the well equipment (22,54,70) and having a surface exposed to well fluids in a downhole location, and an annular ring of volume compensating material (26,64,82) positioned on the body surface exposed to well fluids, the volume compensating material having a resistance to sustain normal fluid head pressures at the downhole location and allowing volume changes responsive to pressures higher than such normal fluid head pressures at the downhole location.

7. An apparatus according to claim 6, wherein the volume compensating material consists of microspheres in a matrix of epoxy.

8. An apparatus according to claim 6 or claim 7, wherein the equipment is a well string (22) and the volume compensating material (26) is installed on the exterior of the well string.

9. An apparatus according to claim 6 or claim 7, wherein the equipment is a pair of concentric well strings (22,24) having an annular space (20) therebetween, and the volume compensating material (26) is installed on one of the strings (22) and exposed to the annular space.

10. An apparatus according to claim 6 or claim 7, wherein the equipment is an annular seal (46) having an upper metal seal (50) lip, a lower metal seal lip (52) and an intermediate resilient seal ring (54) with a recess (66) in the exterior surface of the resilient seal ring, and the volume compensating material (64) is installed in the resilient seal recess.

Patentansprüche

1. Verfahren zum Schutz von Bohrausrüstungen vor sprungartigen Druckanstiegen vor Ort innerhalb eines Bohrloches gekennzeichnet durch Befestigung eines volumenausgleichenden Materials (26, 64, 82) an einem Abschnitt der Bohrausrüstung (22, 54, 70), so daß das volumenausgleichende Material Bohrdrücken im Bohrloch ausgesetzt ist, wobei das volumenausgleichende Material genügend Widerstandsvermögen besitzt, um den normalen Spitzendrücken vor Ort im Bohrloch standzuhalten, jedoch in Reaktion auf Drücke oberhalb solcher normalen Spitzendrücke nachgibt, und durch Absenken der Bohrausrüstung vor Ort im Bohrloch absenkt.

2. Verfahren nach Anspruch 1, gekennzeichnet durch das Schaffen einer schützenden, porösen Fläche (34) zum Schutz des volumenausgleichenden Materials (26) vor dem vor Ort im Bohrloch auftretenden normalen Druck.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet**, daß das volumenausgleichende Material (26) an der Außenseite eines Rohrstranges (22) vor seinem Absenken in das Bohrloch angebracht wird.

4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß das volumenausgleichende Material (64) in einer Ausnehmung (66) in der Oberfläche einer elastischen Dichtung (54) angeordnet ist.

5. Verfahren nach Anspruch 4, **dadurch gekenn-**

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zeichnet, daß die elastische Dichtung (54) zwischen einer oberen Lippendichtung (50) und einer unteren Lippendichtung (52) angeordnet ist.

6. Vorrichtung zum Schutz einer Bohrausrüstung vor sprungartigen Druckanstiegen vor Ort innerhalb eines Bohrloches, gekennzeichnet durch einen Körper, der einen Teil der Bohrausrüstung (22, 54, 70) bildet und eine den Bohrfluiden vor Ort im Bohrloch ausgesetzte Oberfläche besitzt, und durch ein Ringteil aus volumenausgleichendem Material (26, 64, 82), das an der Oberfläche des Körpers, die den Bohrfluiden ausgesetzt ist, angeordnet ist, wobei das volumenausgleichende Material ein Widerstandsvermögen besitzt, um den normalen Spitzendrücken des Fluides vor Ort im Bohrloch zu widerstehen und Volumenänderungen in Reaktion auf Drücke, die höher sind als solche normalen Spitzendrücke des Fluides vor Ort im Bohrloch zu ermöglichen.

7. Vorrichtung nach Anspruch 6, **dachurch gekennzeichnet,** daß das volumenausgleichende Material aus Mikrokugeln in einer Epoxidharz-Matrix besteht.

8. Vorrichtung nach Anspruch 6 oder 7, **dadurch gekennzeichnet,** daß die Ausrüstung ein Rohrstrang (22) ist und das volumenausgleichende Material (26) an der Außenseite des Rohrstranges angeordnet ist.

9. Vorrichtung nach Anspruch 6 oder 7, **dadurch gekennzeichnet,** daß die Ausrüstung aus einem Paar von konzentrisch angeordneten Rohrsträngen (22, 24) mit einem ringförmigen Raum (20) zwischen diesen besteht, und das volumenausgleichende Material (26) an einem der Stränge (22) angebracht ist und in den ringförmigen Raum weist.

10. Vorrichtung nach Anspruch 6 oder 7, **dadurch gekennzeichnet,** daß die Ausrüstung eine ringförmige Dichtung (46) mit einer oberen metallischen Dichtlippe (50) und einer unteren metallischen Dichtlippe (52) sowie einem dazwischenliegenden elastischen Dichtring (54) mit einer Aussparung (66) in der Außenfläche des elastischen Dichtringes ist und das volumenausgleichende Material (64) in der Aussparung der elastischen Dichtung angeordnet ist.

Revendications

1. Procédé de protection d'un équipement de puits vis à vis de pointes de pression dans un emplacement de fond de puits comportant les étapes consistant à fixer un matériau compensateur de volume (26, 64, 82) sur une partie de l'équipement de puits (22, 54, 70) de telle sorte que le matériau compensateur de volume soit exposé aux pressions de puits existant au niveau de l'emplacement de fond de puits, le matériau compensateur de volume ayant une résistance suffisante pour résister à des pressions de tête normales à l'intérieur de l'emplacement de fond de puits mais se rompant en réponse à des pressions situées au-dessus desdites pressions de tête normales, et à abaisser l'équipement de puits dans le puits jusqu'à l'emplacement de fond de puits.

2. Procédé selon la revendication 1, comportant l'étape consistant à fournir une surface de protection poreuse (34) pour protéger le matériau compensateur de volume(26)vis à vis de la pression normale rencontrée au niveau de l'emplacement de fond de puits.

3. Procédé selon la revendication 1 ou 2 dans lequel le matériau compensateur de volume (26) est appliqué sur l'extérieur de la ligne de puits (22) avant d'être abaissé jusque dans le puits.

4. Procédé selon la revendication 1, dans lequel le matériau compensateur de volume (64) est agencé dans une cavité (66) située dans la surface d'un joint élastique (54).

5. Procédé selon la revendication 4, dans lequel le joint élastique (54) est positionné entre un joint à lèvre supérieur (50) et un joint à lèvre inférieur (52).

6. Dispositif pour protéger l'équipement de puits vis à vis de pointes de pression dans un emplacement de fond de puits, le dispositif comportant un corps constituant une partie de l'équipement de puits (22, 54, 70) et ayant une surface exposée aux fluides de puits dans un emplacement de fond de puits, et un anneau circulaire de matériau compensateur de volume (26, 64, 82) positionné sur la surface du corps exposée aux fluides de puits, le matériau compensateur de volume ayant une résistance destinée à soutenir des pressions normales de tête de fluide au niveau de l'emplacement de fond de puits et à permettre des changements de volume en réponse à des pressions plus élevées que de telles pressions normales de tête de fluide au niveau de l'emplacement de fond de puits.

7. Dispositif selon la revendication 6, dans lequel le matériau compensateur de volume est constitué de micro-sphères situées dans une matrice en epoxy.

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8. Dispositif selon la revendication 6 ou 7, dans lequel l'équipement est une ligne de puits (22) et le matériau compensateur de volume (26) est installé sur l'extérieur de la ligne de puits.

9. Dispositif selon la revendication 6 ou 7, dans lequel l'équipement est constitué de deux lignes de puits concentriques (22, 24) ayant un espace annulaire (20) délimité entre elles, et le matériau compensateur de volume (26) est installé sur l'une des lignes (26) et exposé à l'espace annulaire.

10. Dispositif selon la revendication 6 ou 7, dans lequel l'équipement est un joint annulaire (46) ayant une lèvre (50) formant joint métallique supérieur, une lèvre (52) formant joint métallique inférieur et un anneau (54) formant joint élastique intermédiaire muni d'une cavité (66) sur la surface extérieure de l'anneau formant joint élastique, et le matériau compensateur de volume (64) est installé dans la cavité du joint élastique.