Prepacked well screen and casing assembly

The invention relates to wells of all types which require sand control but particularly to deep wells such as those producing oil and/or gas. In deep wells it is extremely costly to complete the well in the producing zone by the conventional techniques of running in casing, cementing, down-hole perforating, running in the screen jacket assembly and then gravel packing with a cross-over tool. The perforating operation is particularly expensive and can be dangerous, since explosives are typically used to form the perforations. Furthermore, it is the usual practice to form a total of only about twelve 19 mm perforations per 305 mm of casing length. The relatively few number of holes and their large size sometimes tends to produce voids or "holidays" in the later installed sand-controlling gravel pack, since a much greater flow velocity exists through each perforation than would be the case if many more perforations were present. The problem of voids in the gravel pack and consequent failure when the fine formation material moves right into the screen and erodes it is especially great when the well hole is highly deviated.

Prepacked screen assemblies have been manufactured in the past and these include a uniform consolidated or unconsolidated annulus of resin-coated sand or gravel which fills the space between a pair of concentric screen members. Prepacked screen assemblies are typically used with an external gravel pack since formation sand would plug their slots. If used in a deep well, such assemblies could not be easily removed in the event of a failure of the internal annular gravel pack, since the prepacked screens are typically made of stainless steel which would be difficult to cut through with a wash-over tool. Furthermore, they would probably tear apart and jam as the wire and rod of which they are made comes apart.

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The resin-coated gravel or sand used in the afore-

mentioned prepacked screen assemblies is preferably of the type described in an article entitled, "Performance Review of Phenolic-Resin Gravel Packing" by Lowell W. Saunders and Howard L. McKinzie which appeared in the February 1981 issue of "JOURNAL OF PETROLEUM TECHNOLOGY" at pages 221-228. Although such gravel has been supplied as part of a precured packing between two concentric well screens, it is usually used as a direct replacement for ordinary gravel packs which are formed in situ. The gravel is supplied in loose form from bags and is cured after installation as a consequence of the relatively high temperature existing in the well. The cured resin-coated gravel is inert to acid but is soluble in basic fluids having a high pH. The latter property makes it simple to easily remove the packing at any time. Another article describing the uses of uncured resin-coated sand and various environments in which it can be used is Paper No. SPE 7004 of A. Richard Sinclair and John W. Graham entitled, "An Effective Method of Sand Control". The paper was presented at a meeting of the Society of Petroleum Engineers of AIME in Lafayette, Louisiana, U.S.A. on February 15-16, 1978.

The present invention seeks to provide a well screen assembly which permits a well to be completed without the use of a down-hole gravel packing operation. The invention also seeks to provide a well screen assembly which provides a large overall flow through an entire gravel pack but a much lower flow rate through any one part of the gravel pack than the conventional technique. The invention also seeks to provide a technique for producing a gravel pack for a well screen which will overcome the void and channeling problems of gravel packs produced down-hole.

According to the invention, a prepacked well screen and casing assembly adapted to be lowered into a well

comprises an outer casing member having a perforated intermediate portion, and unperforated end portions extending from each end of said perforated intermediate portion which end portions have coupling portions at the outer ends thereof, a slotted surface well screen jacket member supported internally of said outer casing member on a generally cylindrical base member, said base member having a longitudinally extending perforated intermediate portion located within said well screen jacket member and unperforated portions defining the ends of said base member which are outside said well screen jacket member, a pair of annular metal plates secured between said end portions of said base member and said outer casing member, each said plate defining one end of an annular chamber which extends axially beyond a respective end of said well screen jacket member, and a consolidated packing of porous material within said annular chamber.

Desirably, the outer casing member is sized so that, when the assembly is to be used, it can be mounted "down-hole" by a conventional liner hanger. The liner hanger can engage and be retained near the bottom of the inner wall of the lowermost previously installed casing section. The said last mentioned section would of course have a larger diameter than the casing portion being hung from its internal wall. The perforations in the outer casing member can be formed therein before assembly and preferably are made by the same type of conventional perforating apparatus used to drill patterns of holes in the pipe base portion of a pipe base well screen. A typical pattern would be to have 12.7 mm I.D. holes arranged circumferentially on 25.4 mm centres with the holes in alternate rows being offset. Thus, a casing member having a 244 mm O.D. can have two hundred and sixty four 12.7 mm holes per 30.5 cm as compared to only about twelve 19 mm holes per 30.5 cm which are typically provided when a casing must be perforated "down-hole".

As previously discussed, this greatly increases the uniformity of flow through the assembly and minimizes plugging and channeling.

The base member for the well screen jacket member of the assembly is left unperforated near its ends and is perforated in its central region wherein the well screen jacket is located. The well screen jacket would normally be welded to the base member at both ends. However, where the well screen and casing assembly is to be used in a high temperature environment, wherein the different temperature coefficients of expansion of a stainless steel screen jacket member and a carbon steel base member could cause buckling, the screen jacket could be welded to the base member at just one end. The other end of the screen jacket could then be shrunk-fit to the base member as is disclosed in US Patent No. 4,378,840. The shrunk-fit end would be capable of sliding on the base member to relieve stresses at high temperatures. Although the base member for the screen jacket would normally be a cylindrical pipe, it could also be formed of welded channels as disclosed in United States Patent No. 4,096,911 (Geske).

After the intermediate portion of the outer casing member has been perforated and the screen jacket member has been attached to its support member, a first annular plate is welded to one unperforated end portion of the support member. The well screen with the said plate attached is then located inside the outer casing member and the plate is welded to the inner wall of one unperforated end portion of the outer casing member so as to centralize the well screen within the outer casing member. The casing well screen assembly is then positioned vertically and its outer perforated surface is temporarily covered by a fabric, a metal fine mesh cloth, or a sleeve, for example. The covering can be of any suitable material

which will block off the outer ends of the perforations while loose resin-coated sand or gravel or other porous material is loaded into and consolidated in the perforations and in the annular space defined by the outer casing member, well screen jacket member and first annular plate. A second annular plate can then be placed on top of the porous material and welded to the upper unperforated portions of the outer casing member and to the well screen support base member. The entire assembly including the temporary covering is then cured such as by the use of dry heat in an oven or by steam or hot water, for example, until the resin-coated particles are fused together in a unitary consolidated mass. At this stage, the casing covering can be removed since the particles are no longer able to fall out of the perforations. The amount of resin coating on the particles should be just sufficient to bond adjacent particles without significantly reducing the porosity of the consolidated mass. The size of the particles would be selected in relation to the width of the slots in the screen jacket and the size of the particles in the formation in accordance with the usual practice in the industry.

By using an easily machinable material for the annular plates, it would be possible, any time after the casing and screen assembly was installed, to remove and replace the screen assembly independently of the casing in a wash-over operation without affecting the liner. A new ordinary screen could then be installed and gravel packed in the usual fashion. Furthermore, if the consolidated packing should somehow become defective while the screen remained intact, after removing the upper annular plate, the packing could be removed by injecting a high pH fluid which would dissolve the resin bonds between the particles. A new gravel pack could then be installed in the conventional fashion. It is anticipated that there will be little if any need

to perform the aforementioned operations since the bonded and consolidated packing should obviate channeling and the slot erosion which results. Also, the large number of casing perforations should resist plugging and should result in a relatively uniform flow distribution through the entire annular packed area. This is a considerable advantage over prior art prepacked screens in which the very small width screen slots can be susceptible to plugging by the formation materials. Furthermore, the jacket strength of prior art prepacked screens would normally be insufficient to replace the normal casing. In addition, prior art prepacked screens require specialized installation equipment which is costly and time-consuming to use compared to a prepacked well screen and casing assembly according to the present invention with its rugged exterior. Also, the potential for damage to the rather fragile screen slots of a conventional prepacked screen during shipping or installation is significant.

One embodiment of prepacked well screen in accordance with the invention will now be described, by way of example, with reference to the accompanying drawing, in which the prepacked well screen and casing assembly is indicated generally at 10 and comprises a length of well casing 12 which might typically be of a length of 1 to 13.5 metres. The ends of the casing are preferably provided with threads 14 which permit the particular length of casing to be joined to other lengths in the usual fashion. Before the casing 12 is assembled into the assembly 10, it is perforated in the intermediate region defined between upper and lower annular plate members 18, 20. Since it is much easier to drill holes in the casing 12 when it is out of the ground than it is to perforate it while it is down in a hole, it is possible to provide the casing with a very large number of holes. For example, a casing having an outer diameter of 244 mm can be provided with two hundred and sixty

four 12.7 mm holes twenty two per 30.5 cms when the holes are on 25.4 mm centres whereas a typical down-hole perforated casing would have only about twelve 19 mm holes per 30.5 cms of length. By having a larger number of holes, it is possible to have a large volume of flow but a relatively uniform, and low, rate of flow through the packed bed of gravel 26 which is positioned in the annular space defined between the casing 12, the annular plates 18, 20 and a slotted screen jacket 30. The screen jacket 30 is preferably formed of wire 34 which is helically wound and welded to screen support rods 36 so as to form a continuous slot 38 of constant width, typically 0.152 mm to 0.305 mm. The screen jacket 30 has end portions such as rings 40 which may be welded to a pipe-base support member 42. The pipe-base support member 42 is perforated with holes 44 inside the screen jacket 30 but is unperforated at its ends.

The manufacturing technique has been previously discussed as have the techniques for mounting the pre-packed well screen and casing assembly in a well. Obviously, since the ends of the length of well casing 12 are threaded, a plurality of assembly sections 10 could be joined together with conventional couplings (not shown). There would be no need to have the cylindrical support bases 42 of connected assemblies joined since the bases are affixed and sealed relative to the casing 12 by the welded-in-place plate members 18, 20. The hole diameter and spacing pattern for the holes 22 in the casing member 12 and for the holes 44 in the base member 42 is preferably selected so as to maximize the flow area while maintaining sufficient structural strength. Likewise, the hole diameter and spacing pattern for the holes 44 in the pipe-base support member 42 is designed to maximize flow area while maintaining sufficient structural strength in the member 42. Due to the difference in diameters of the casing 12 and the pipe-base support member 42, the total number of the casing

holes 22 would normally exceed the number of the base member holes 44, and the diameter of the holes 22 would normally be greater than that of the holes 44. For example, the holes 22 might have a diameter of 12.7 mm while holes 44 are 9.52 mm. By providing many more holes in the casing 22 than can be achieved with down-hole perforating equipment, the potential for channels developing in the pack of gravel 26 is substantially eliminated. Also, voids and "holidays" which are so common in down-hole-formed gravel packs can be eliminated when the resin-coated packing gravel is assembled to the casing and screen assembly in a factory or other above-ground location. In such a controlled environment, good consolidation can be achieved by vibrating the assembly or using other compaction techniques as required. The use of an above-ground curing operation while the casing perforations are covered, assures that no change will take place in the location of the gravel particles. Thus, a more consistent pack can be achieved than would appear to be possible in a down-hole cure of a down-hole-installed gravel pack utilizing uncured resin-coated gravel.

Although it has been noted that there is no need to have the cylindrical support base members 42 of adjacent assemblies acutally connected together, since they are each sealed relative to the casings 12, there are situations wherein it may be desirable to provide each end of the pipe base member 42 with threads. For example, where several sections of screen assemblies 10 are to be placed in a well and there is some possibility that one or more of the lower sections might have to be sealed off at some date in the future, it would be advantageous to be able to thread a conventional "seal bore sub" to the lower end of at least some of the members 42. The upper ends of the pipe base members 42 which would underlie the lower ends of other members 42 through which

a "seal bore sub" is to be passed could be fitted with conventional "landing nipples". Each "landing nipple" has a smooth bore into which the "seal bore sub" can be lowered from the adjacent assembly. Sealing rings on the exterior surface of the "seal bore sub" cause a fluid-tight connection. When it is deemed desirable to shut off production from a lower screen, a "seal bore sub" can be lowered by a cable through the successive pipe base members 42 until the "landing nipple" to be sealed is reached. At this point, the "seal bore sub" is expanded into sealing engagement with an internal groove in the "landing nipple". The aforementioned optional sealing structure does of course add to the cost of the installation but can be extremely cost effective in formations wherein a possibility exists that a lower screen might start pumping sand much sooner than an upper one or where production from a lower strata might become undesirable.

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CLAIMS

1. A prepacked well screen and casing assembly adapted to be lowered into a well comprising an outer casing member having a perforated intermediate portion, and unperforated end portions extending from each end of said perforated intermediate portion which end portions have coupling portions at the outer ends thereof; a slotted surface well screen jacket member supported internally of said outer casing member on a generally cylindrical base member, said base member having a longitudinally extending perforated intermediate portion located within said well screen jacket member and unperforated portions defining the ends of said base member which are outside said well screen jacket member; a pair of annular metal plates secured between said end portions of said base member and said outer casing member, each said plate defining one end of an annular chamber which extends axially beyond a respective end of said well screen jacket member; and a consolidated packing of porous material within said annular chamber.

2. A prepacked well screen and casing assembly according to claim 1, wherein said porous material comprises particulate material, the particles of which are bonded together.

3. A prepacked well screen and casing assembly according to claim 1 or claim 2, wherein said particulate material is resin-coated gravel or sand.

4. A prepacked well screen and casing assembly according to any preceding claim, wherein said perforated intermediate portions of said outer casing member and said base member have patterns of hole perforations which are at least substantially the same in diameter and spacing.

5. A prepacked well screen and casing assembly

according to any of claims 1 to 4, wherein said outer casing member contains a greater number and a larger total area of perforations than said base member.

6. A prepacked well screen and casing assembly according to claim 3, wherein said resin-coated gravel or sand has its resin coating cured by heat so that individual particles are bonded into a consolidated mass, said coating being sufficiently thin to permit fluid flow through the mass in the space between particles.

7. A prepacked well screen and casing assembly as claimed in any preceding claim in which each annular plate is of softer material than that used for the well screen jacket member.

8. A prepacked well screen and casing assembly substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawing.

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