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Flexible Sand Barrier (FSB): A Novel Sand Control System

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ABSTRACT

A series of experiments were conducted to determine the utility of a Flexible Sand Barrier (FSB) (helically wound flexible metal tubing) as a permeable casing within horizontal boreholes. These experiments focused on its production capacity and filtering capability. A test cell was developed which allowed testing over a range of pressure drops with or without a gravel pack. Laboratory in flow tests indicated 0.10 to 0.21 m^3/d per meter (0.2 to 0.4 bbl/d per foot) of FSB in a 30 psi (0.21 MPa) reservoir with 1.0 Pa s (1000 cp) oil. Several configurations of the product from various manufacturers were compared and a suitable candidate was chosen for field testing which is underway.

INTRODUCTION

An innovative drilling technology, the Ultrashort Radius Radial System (URRS)[1] has been developed which allows horizontal drain holes (radials) to be drilled from existing well bores (Figure 1). These radials are drilled with a non-rotating, Conical Jet drillhead[2] shown in Figure 2 which is advanced into the formation through an ultra short radius (0.32 m) (12 inch) 90 degree whipstock. The drilling fluid, normally water, is delivered to the drillhead through a continuous length of 32mm (1.25 inch) outside diameter by 25 mm (1.0 inch) inside diameter ERW (electric resistance welded) tubing at 55 to 69 MPa (8,000 to 10,000 psi) and 9.5 to 13.0 l/s (150 to 200 gpm). The geometry of the resulting horizontal bore hole is determined by formation parameters and the rate of advance of the drillhead. In unconsolidated formations the horizontal bore hole diameter is 50 to 100 mm (2 to 4 inches). When the desired radial bore hole length has been achieved, routinely between 10 and 30 m (30 and 90 feet) drilling is stopped and the radial tube is positionally surveyed by a Radius of Curvature tool shown in Figure 3. The drillhead is then cut off using an ECM (electro chemical machining) technique.

At this point, the radial tube is directly accessible from the surface via the vertical work string and the radial tube can serve as a conduit for any of several completion options. The first option is that the 32 mm (1.25 inch) radial tube can be perforated and/or cut off at the exit of the whipstock again utilizing ECM methods. The 32 mm (1.25 inch) radial tube remains in place as a casing. A second option is to transport properly sized gravel in two lifts so as to completely fill the annulus formed by the horizontal bore hole and the radial tube thus forming a horizontal gravel pack[3] along its length as shown in Figure 4. A third option is to place and anchor a Flexible Sand Barrier (FSB) in the horizontal bore hole by means of the radial tube. The radial tube is subsequently pulled back through the whipstock leaving the FSB in place as a combined horizontal permeable production tube and sand barrier.

Although these completion alternatives can be combined in any number of ways, this paper is directed to the third option: Placement of the FSB in the horizontal bore hole.

THEORY AND DESCRIPTION OF THE FLEXIBLE SAND BARRIER (FSB)

The Flexible Sand Barrier (FSB) is a flexible, jointed permeable tube constructed of a helically wound metal strip as shown in Figure 5. The tube is formed from a single thin narrow metal strip which is folded and wrapped into itself. The degree of infolding or interlock of this joint influences both the filtering properties and the axial or tensile strength of the FSB. As well, the degree of interlock determines the flexibility or allowable bend radius of a particular diameter FSB tube. Because the FSB is formed of a single metal strip, the FSB can be constructed of any ductile material which can be plastically deformed into the interlocking joint.

The FSB can provide a range of varying passageway shapes, which are dependent upon the construction of the interlocking strip material. The passage shape can vary, but in general, the flexible joint provides a helical passage with an S-shaped cross section. The joint configuration can be wide or narrow depending upon whether the flexible tube is pulled into an open or closed position, as shown in the cross section of Figure 5. The degree of openness can be

References and illustrations at end of paper.

adjusted by tension load on the FSB. The selected degree of openness can be fixed by an internal structure attached to the FSB.

Considering the FSB as a filter, the fluid flows from outside through the passageway into the interior of the FSB. The sand or formation material collects on the outside and builds a particle bridge over the helical joint. This particle bridge acts as a sand filter. Some fine formation sand may pass through the helical joint depending upon the size of particles, the viscosity of the fluid, and the degree of the joint openness.

Because of capability for movement, the FSB can adjust to temperature changes and thus should preclude damage therefrom in thermal recovery applications.

The final configuration of the FSB in a set of horizontal radial bores is shown in Figure 7 and an overall embodiment in terms of multiple radials is shown in Figure 8.

APPLICATION

The Flexible Sand Barrier (FSB) can be applied as a sand barrier for horizontal, deviated, and vertical wells. This paper focuses on horizontal application.

In placing the FSB, it is pumped down the 32 mm (1.25 inch) radial tube and out of the cut off end, as previously described. To provide the placement and pumpdown mechanism, three components are placed at the anterior or nose of the FSB. The first is an expanding set of barbs on a spear as shown in Figure 6. The barbs are compressed when it is pumped down. When it exits the open end of the 32 mm (1.25 inch) radial tube, the barbs spring open and engage the formation, thus anchoring the FSB to the formation.

In order to pump down the FSB, a set of chevron seals is also provided at its nose, posterior to the barb anchor. These seals provide the means by which the FSB can be pulled down the radial tube under fluid pressure. When the FSB reaches the open end of the radial tube, the barbs exit followed by the sliding chevron seal. At that point there is no longer any sealing means by which fluid can pull the FSB along the radial tube and the FSB stops.

The next step in placement is to withdraw the 32 mm (1.25 inch) radial tube by pulling on its posterior with an overshot or spear (Bowen spear) placed into its open tail. This overshot or spear is lowered down the vertical working string via sucker rods. Upon engagement with the open tail of the FSB, the sucker rods are pulled back and draw back the 32 mm (1.25 inch) radial tube. The result is that the bare FSB is left in place as a conduit and sand filter within the horizontal bore hole. Suitable sized screens are placed on both ends of the FSB shown as a Tail Filter (and comparable nose filter) in Figure 6. The net result is a suitably flexible, permeable casing which also serves as a sand barrier.

DATA AND RESULTS

In the laboratory, several different types of FSB were investigated in terms of fluid throughput, sand exclusion, tensile, and compressive strength in a test cell. The test cell was developed such that a sample length of the FSB could be sealed concentrically within a larger impermeable tube. The FSB on test was sealed at both ends of the test cell so that the internal pressure of the test FSB remained atmospheric along its full length. The annulus between the outer tube and the test FSB could be packed with sand or left empty as required. A constant pressure oil reservoir was connected to the annulus around the FSB which allowed fluid to flow into the annulus, through the sand pack, if present, through the test FSB and out of cell.

To achieve reproducible results, SAE 90 weight gear oil was used, as was sand modelled after Tangleflags formation reservoir near Lloydminster, Saskatchewan. This formation represents a wide spectrum of particle sizes as can be seen in Table I.

The variables examined included pressure drop across the cell, type of joint interlock, and degree of joint openness. The resulting data was in terms of fluid production rate versus pressure drop and weight of sand per liter throughput into the FSB.

Typical results for this test arrangement are shown in Figure 9.

Compressive strength of a typical 3/4-inch (19 mm) standard FSB as measured between two flat plates was 6.9 MPa (1000 psi). Tensile strength is a function of interlock joint design, the strength and thickness of the metal strip comprising the FSB.

Sand throughput of Tangleflags formation indicated initially essentially all particles larger than a few microns were screened out by the FSB.

Field testing of the selected FSB is underway.

CONCLUSION

A novel flexible permeable casing called the Flexible Sand Barrier (FSB) for horizontal, deviated, or vertical wells has been developed and tested in the laboratory. Typical results for a 3/4-inch (19 mm) FSB with Tangleflags sand with approximately 1.0 Pa s (1000 cp) oil indicates a throughput of 0.10 to 0.21 m^3/d per meter (0.2 to 0.4 bbl/d per foot) of FSB in a 6.9 MPa (30 psi) reservoir. With the wide spectrum of Tangleflags particle size, almost all sand above a few microns was excluded. The design of the FSB is particularly adapted to thermal applications. The advantages of the FSB as compared to conventional slotted liners include lower cost, ease of placement, adaptability to thermal production, and a suggestion of self cleaning action with movement.

ACKNOWLEDGMENTS

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Table I: Sand Size Distribution

Tangleflags A13-33-50-25

Mesh #	Cumulative %	Fraction %
60	8.31	8.31
80	25.37	17.06
100	67.11	41.74
120	80.45	13.34
140	89.57	9.11
200	95.61	6.03
325	98.89	3.44
325+	100.00	0.97

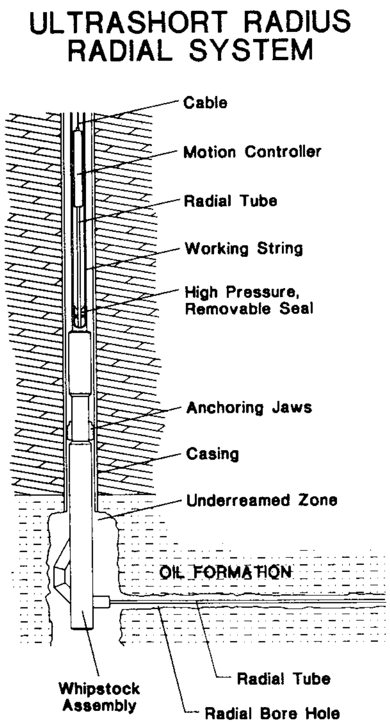

Figure 1. Ultra Short Radius Radial System

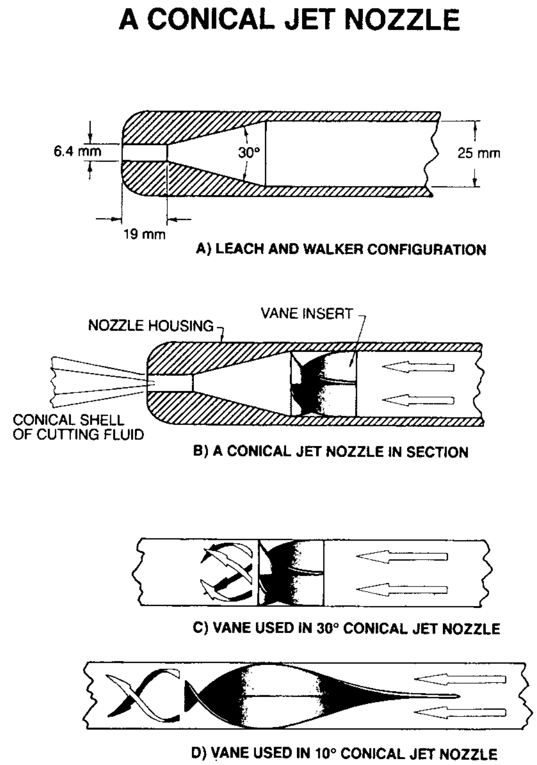

Figure 2. Conical Jet Nozzle

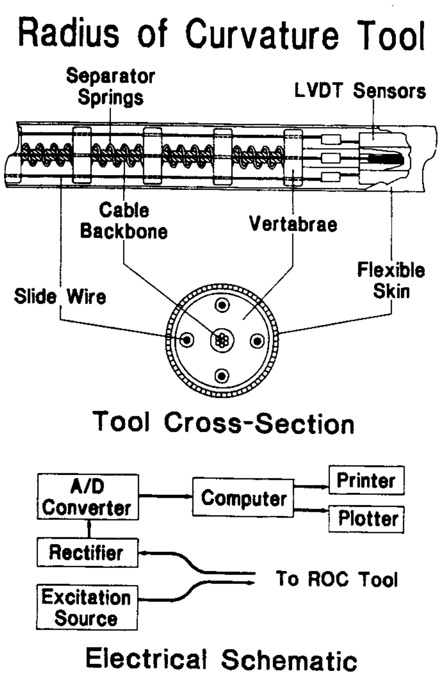

Figure 3. Radius of Curvature Tool

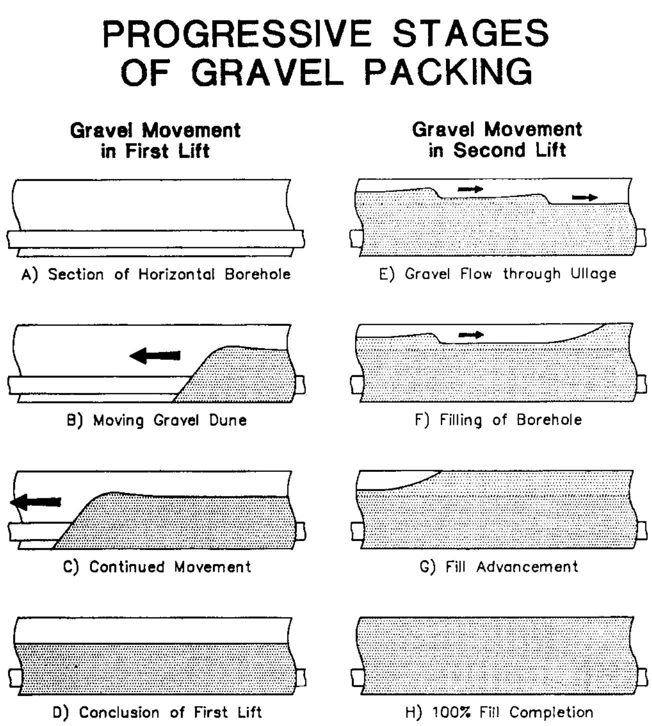

Figure 4. Progressive Stages of Gravel Packing

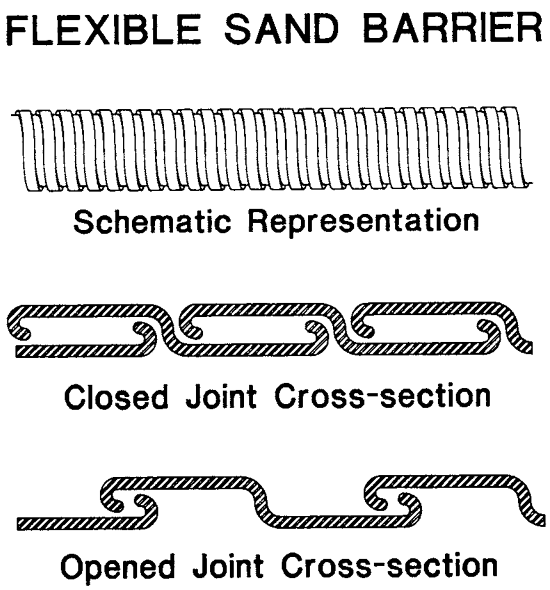

Figure 5. Flexible Sand Barrier (FSB)

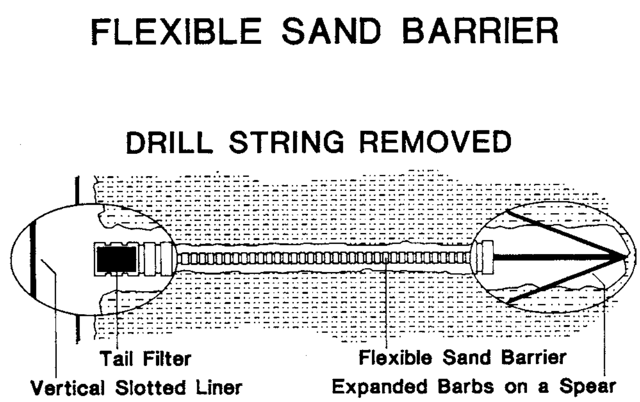

Figure 6. Flexible Sand Barrier (FSB) as Installed

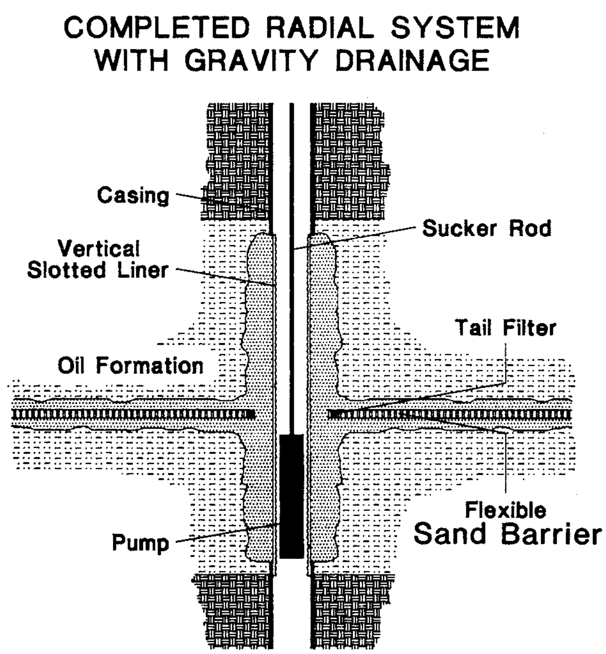

Figure 7. Completed Radial System with Gravity Drainage

MULTIPLE RADIAL COMPLETION

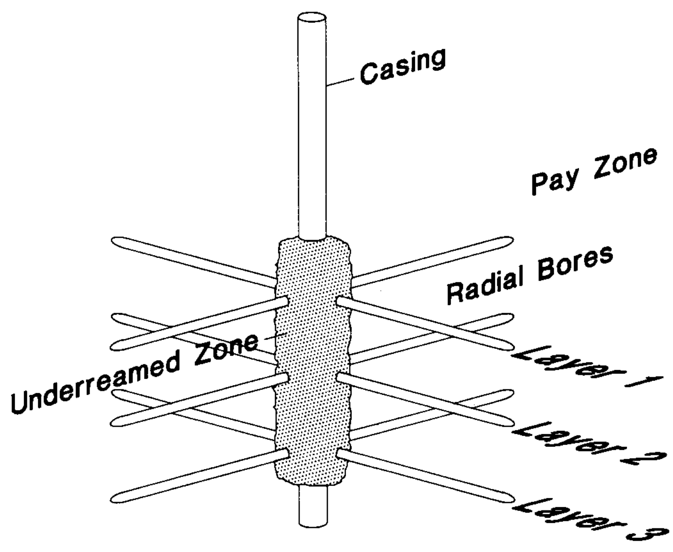

Figure 8. Typical Multiple Radial Completion

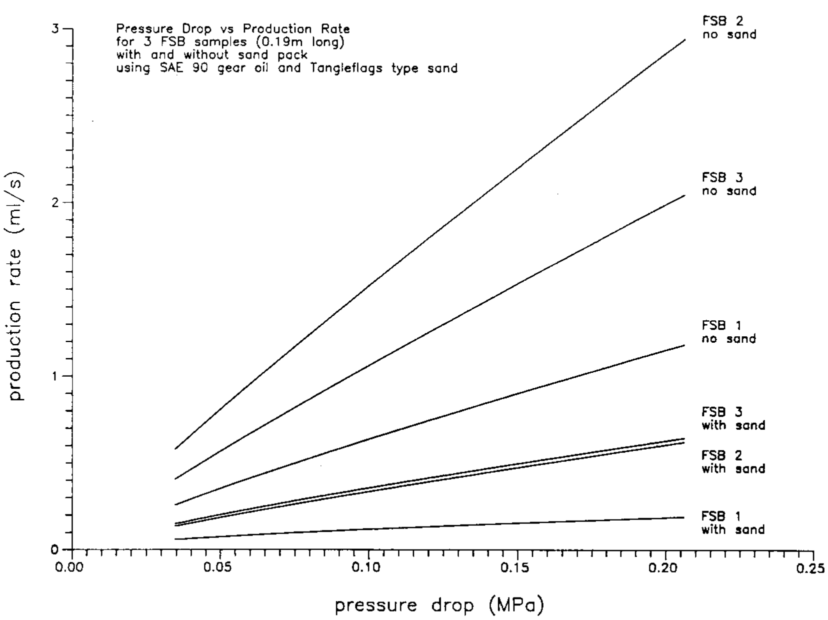

Figure 9. Pressure Drop versus Production Rate for FSB