

FracBlack™

Proppant for Partial Monolayers

Improved Ultra-Lightweight Proppant Technology!

FracBlack™ is a new Ultra-Lightweight (ULW) proppant designed for use in partial monolayer fracture stimulation applications. It is a thermally-cured, chain-entangled thermoset nanocomposite bead, wherein an intimately dispersed nanofiller provides strong reinforcement. The product represents a breakthrough in ULW proppant technology and is subject to ongoing performance improvements and optimization. The specifications provided in this document are therefore potentially subject to further improvements.

Utilization: FracBlack™ can be used in partial monolayers to provide excellent closure resistance in oil and gas reservoirs. Closure stresses of up to 6000 psi (41.4 MPa), at temperatures of up to 220 °F (104 °C) are within the performance range. The low specific gravity of FracBlack™ approaches that of water, allowing for excellent proppant distribution throughout the fracture network.

Technical Data:

- ◆ *Density:* 1.054 g/cm³ (65.8 lbs/ft³).
- ◆ *U.S. Mesh Size:* 14/40 & 40/100.
- ◆ *Glass Transition Temperature:* Approximately 266 °F (130 °C).
- ◆ *Toxicity:* None.
- ◆ *Baseline Fracture Conductivity:* See next three pages for measurements of static conductivities of partial monolayers measured thus far in ongoing tests at a loading of 0.02 lb/ft² (0.09765 kg/m²) (14/16 mesh size, Ohio sandstone).
- ◆ *ISO 13503-2:2006 Specifications:* See the last page of this document.

Advantages Beyond Conventional Proppants:

- ◆ Lightest proppant on the market for partial monolayer and gravel pack applications.
- ◆ Allows use of slickwater carrier fluids to minimize reservoir damage.
- ◆ Will not crush, chip, break, or otherwise generate migrating fines like other proppants.
- ◆ Perfectly smooth and spherical - once locked in place, proppant will deform into a smooth disk.
- ◆ Non-abrasive - will not damage tubing or surface equipment during use.
- ◆ Manifests excellent dissipation of static electricity, facilitating ease in handling.
- ◆ No sticky resin coatings to mess up your equipment.

Product Testing and Limitations:

- ◆ The use of this product as a proppant is protected by U.S. Patent #s 6,248,838 and 6,451,953; U.S. Patent Application #s 20070021309, 20070066491, 20070161515 and 20070181302; and other patents pending.
- ◆ Prospective customers are encouraged to review recent SPE papers on Ultra-Lightweight proppants. Reference numbers are available upon request.

Packaging and Delivery: Available in super sacks FOB Belle Chasse, Louisiana.

Pricing: Please inquire.



Sun...The HOLE Solution Company!

1-800-962-6490

www.sundrilling.com

FracBlack™

Proppant for Partial Monolayers

BASELINE FRACTURE CONDUCTIVITY MEASUREMENT PROCEDURES:

Partial monolayers of U.S. 14/16 mesh size [diameters ranging from 0.0469 to 0.0555 inches (1.19 to 1.41 mm)] beads were used at a loading of 0.02 lb/ft² (0.09765 kg/m²) in Ohio sandstone. Deoxygenated silica-saturated 2% potassium chloride (KCl) brine of pH 7 was used as the test fluid in most experiments. Crude oil was used as the test fluid in one experiment to assess the effects of changing the test fluid. Tests were performed according to International Standard ISO 13503-5, “*Petroleum and Natural Gas Industries - Completion Fluids and Materials - Part 5: Procedures for Measuring the Long-Term Conductivity of Proppants*” (final draft, 2006), except for the following differences in the testing procedure:

1. Section 10.2.3 refers to a method for pouring the proppant into the test cell. For partial monolayers, the proppant was placed manually, approximately evenly over the rock face.
2. Section 12 specifies 50 hour stress periods ramping by 2000 psi intervals. In obtaining the static conductivity data reported on the next page, the stress was held constant for more than 1000 hours at a single stress level in order to observe the behavior of the conductivity of a partial monolayer at each given combination of closure stress and temperature over very long periods.

The conductivity test conditions used in this work can be summarized as follows: 20.68 MPa (3000 psi) at 71.1 °C (160 °F) in brine; 27.58 MPa (4000 psi) at 87.8 °C (190 °F) in brine; 34.47 MPa (5000 psi) at 104.4 °C (220 °F) in brine; 41.37 MPa (6000 psi) at 93.3 °C (200 °F) in brine; and 41.37 MPa (6000 psi) at 93.3 °C (200 °F) in crude oil. In the crude oil test, for reasons related to practical ease of implementation, the cell was first equilibrated by using brine as the fluid, and brine was then replaced by crude oil over the time range of 94 to 142 hours after the inception of data collection. The fracture width was also recorded along with the conductivity at each measurement of a data point in each test.

RESISTANCE TO MIGRATION:

Sparse partial monolayers of FracBlack™ beads of narrow polydispersity manifest excellent resistance to migration and to the formation of fines under conditions of rapid and/or surging fluid flow since the beads are “locked in place” by the closure stress. This fact was demonstrated in a fluid surge experiment that was run on the partial monolayer under a closure stress of 20.68 MPa (3000 psi) at a temperature of 71.1 °C (160 °F) in brine. Eight brine surge flows were run through the pack after the conclusion of the static conductivity measurement by varying the differential pressure stepwise across the pack from a minimum of 2 psi up to a maximum of 197 psi. The resulting pressure gradient across the pack ranged between 4 psi/ft and 338 psi/ft. Fracture width measurements were made after each surge flow to see if there was any indication of proppant migration. In addition, the effluent was monitored for fines production. It was found that the fracture width remained constant at 0.38 mm and that there was zero production of fines. These results show that the use of a partial monolayer with a narrow bead size distribution provides the maximum benefit in terms of width retention, porosity retention and stability.



Sun...The HOLE Solution Company!

1-800-962-6490

www.sundrilling.com

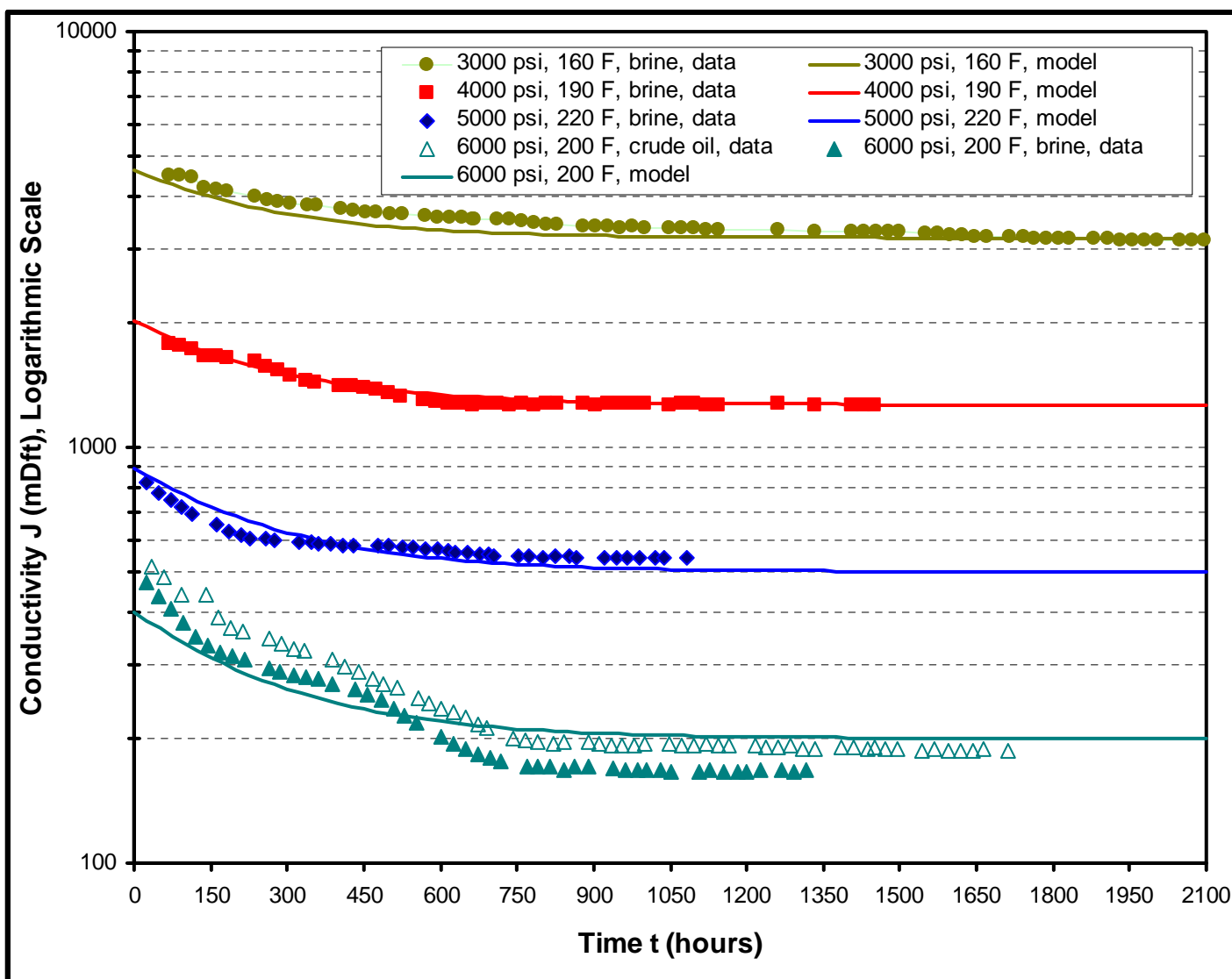
FracBlack™

Proppant for Partial Monolayers

BASELINE FRACTURE CONDUCTIVITY DATA AND MODEL:

Partial monolayers of U.S. 14/16 mesh size beads were used at a loading of 0.02 lb/ft² in Ohio sandstone. Each curve is labeled by the closure stress (S), temperature (T), and type of fluid. The following simple 5-parameter empirical (curve fitting) model equation is applicable for 3000 ≤ S ≤ 6000 psi, 160 ≤ T ≤ 220 °F and 0 ≤ t ≤ 2100 hours, and should not be used to extrapolate outside these limits:

$$J \approx 5.0986 \cdot 10^4 \cdot \exp(-9.2404 \cdot 10^{-4} S) + 1.0516 \cdot 10^4 \cdot \exp(-6.5802 \cdot 10^{-4} S - 3.8979 \cdot 10^{-3} t)$$



Sun...The HOLE Solution Company!

1-800-962-6490

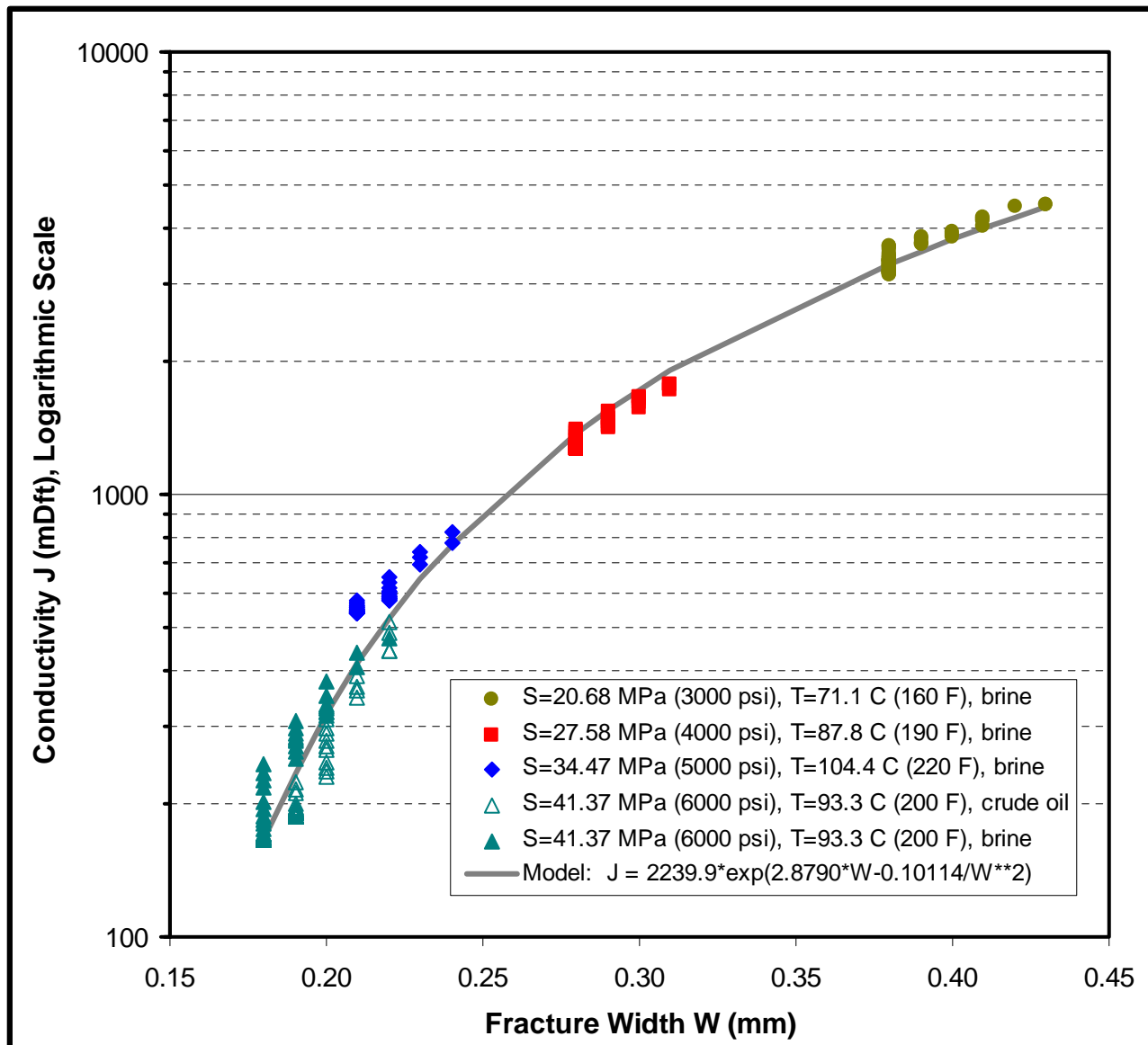
www.sundrilling.com

FracBlack™

Proppant for Partial Monolayers

RELATION BETWEEN CONDUCTIVITY AND FRACTURE WIDTH:

It is shown below that sparse partial monolayers of FracBlack™ owe their ability to allow the flow of liquids for prolonged periods under demanding test conditions to the fact that they can keep a fracture propped open (maintain significant fracture width) for prolonged periods under such conditions. Note also that all of the data can be described with a simple 3-parameter empirical (curve fitting) equation.



Sun...The HOLE Solution Company!

1-800-962-6490

www.sundrilling.com

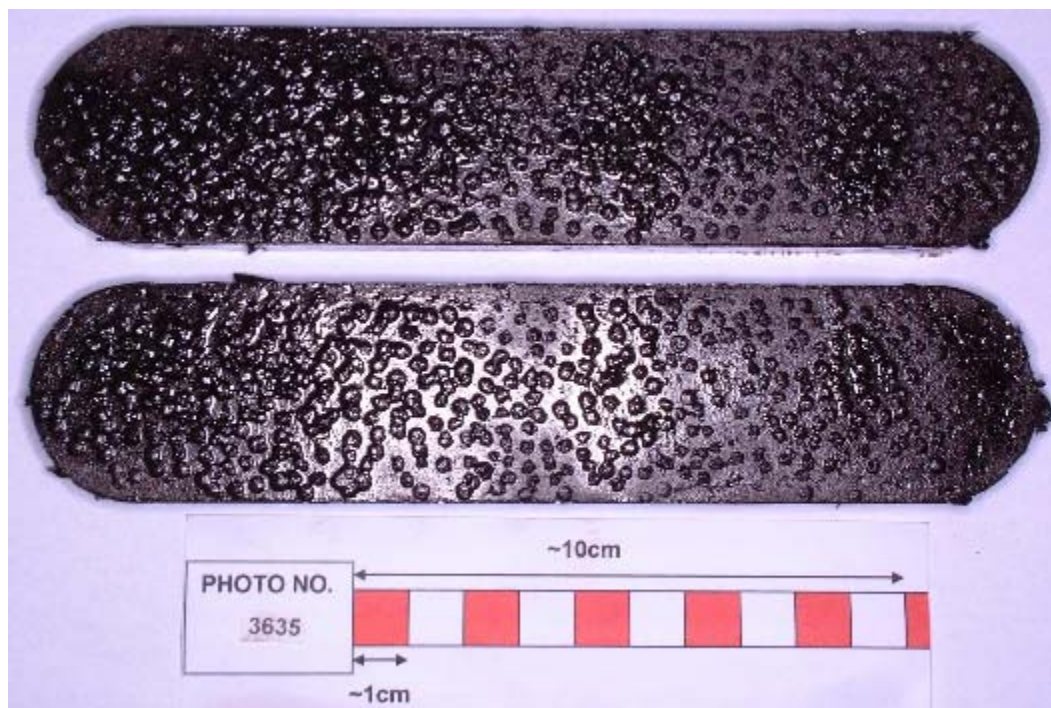
FracBlack™

Proppant for Partial Monolayers

PHOTOGRAPHS OF FracBlack™:

The small photograph on the left below shows some “dry” beads. The very high sphericity and roundness of the beads can be seen readily by visual inspection.

The larger photograph on the right below was taken at the end of a conductivity test using a partial monolayer [loading of 0.02 lb/ft² (0.09765 kg/m²)] under a closure stress of 41.37 MPa (6000 psi) at a temperature of 93.3 °C (200 °F) for 1710 hours. The fluid (brine during the first 142 hours, crude oil during the remaining 1568 hours) flowed from right to left during the experiment.



Note that, even after testing under these very rigorous conditions, this sparse partial monolayer looks essentially intact. Closer examination of recovered beads after ending the experiment showed that they had been flattened considerably as a result of the prolonged application of a high closure stress at an elevated temperature, but that there had been little generation of fines resulting from brittle fracture.



Sun...The HOLE Solution Company!

1-800-962-6490

www.sundrilling.com

FracBlack™

Proppant for Partial Monolayers

CYCLIC LOADING RESISTANCE:

After the last static conductivity data point was taken in the test under a closure stress of 27.58 MPa (4000 psi) at a temperature of 87.8 °C (190 °F), 30 unloading-reloading cycles of 4000 psi - 1000 psi - 4000 psi were performed at a rate of 100 psi/minute. The data point taken upon the completion of this dynamic fatigue cycling showed a conductivity of 1212 mDft which is only 4.2% lower than the conductivity of 1265 mDft measured as the last data point of the static conductivity portion of the experiment. This result shows the excellent cyclic loading resistance of FracBlack™.

COMPATIBILITY WITH LIQUID CARBON DIOXIDE STIMULATION PROCEDURES:

FracBlack™ is compatible with liquid CO₂ stimulation procedures. Testing indicated only a very small reduction, within the margin of error of the measurements, in the conductivities of partial monolayers consisting of beads that had been first soaked in liquid CO₂ under a pressure of 20 MPa (2900 psi) at a temperature of 104 °C (220 °F) for one hour.

ISO 13503-2:2006 SPECIFICATIONS:

Testing was carried out exactly in accordance with International Standard ISO 13503-2, “*Petroleum and Natural Gas Industries - Completion Fluids and Materials - Part 2: Measurement of Properties of Proppants Used in Hydraulic Fracturing and Gravel-Packing Operations*” (first edition, 2006). The sample splitting instructions provided in Section 5.2 were used in representative sample preparation. The results are summarized below. The relevant section of ISO 13503-2:2006 is also indicated for each test.

TEST	SECTION	RESULT	COMMENTS
Crush Resistance	11	0.0 % fines generation	measured by mass, under 41.37 MPa (6000 psi) load
Sphericity	7	0.9 ± 0.0	0.9 for each of 20 sample beads
Roundness	7	0.9 ± 0.0	0.9 for each of 20 sample beads
Acid Solubility (%)	8	1.28 ± 0.06	measured by mass
Turbidity (FTU)	9	29	measured using spectrophotometer
Bulk Density (g/cm³)	10.3	0.66 ± 0.01	none
Absolute Density	10.5	1.054 ± 0.011	none



Sun...The HOLE Solution Company!

1-800-962-6490

www.sundrilling.com