FRACBLACK HT™

ULW PROPPANT FOR ENHANCED PLACEMENT & CONDUCTIVITY

IMPROVED ULTRA LIGHT WEIGHT PROPPANT TECHNOLOGY

FracBlack HT™ is the third generation Ultra Light Weight (ULW) proppant designed for use in far field fracture stimulation applications in horizontal unconventional well environments. It is an advanced thermoset nanocomposite bead, wherein an intimately dispersed nanofiller provides strong reinforcement. It can be used at closure stresses up to 8000 psi and temperatures approaching 275°F to provide substantial conductivity in the far field. This breakthrough ULW proppant provides technical resolution to the primary limitations which impair conventional proppant placement and performance. The material's high strength and near neutral specific gravity are designed to optimize proppant transport, placement and longevity.

Utilization: FracBlack HT™ is used to provide excellent closure resistance in oil and gas reservoirs throughout the fracture matrix due to the low specific gravity. The addition of 3%-5% by weight to sand has been shown to have significant production increases over sand alone.

Technical Data:

- *Density:* 1.054 g/cm^3
  - 41.2 lbs/ft^3 Bulk Density
  - 65.8 lbs/ft^3 Absolute Density
- *U.S. Mesh Size*: 14/40 and 30/80
- *Glass Transition Temperature:* Approximately 293°F (145°C)
- *Toxicity:* None
- *Baseline Fracture Conductivity:* Data follows showing long-term conductivity data for a loading (surface coverage) of 0.02 lb/ft^2 (0.09765 kg/m^2) (14/16 U.S. mesh size, using Ohio sandstone)
- *ISO 13503-2:2006 Specifications:* See the last page of this document.

Advantages Beyond Conventional Proppants:

- Lightest proppant on the market for far field placement and gravel pack applications.
- Allows use of slick water carrier fluids to minimize reservoir damage.
- Will not crush, chip, break, or otherwise generate migrating fines like conventional proppants.
- Physically smooth and spherical.
- 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.
- Will not embed in most formations.

Product Testing and Limitations:

- The use of this product as a proppant, and its modifications, and in other downhole applications is protected by U.S. Patents numbered 6248838, 6451953, 7803740, 7803741, 7803742, 7902125, 8006754, 8006755, 8088718, 8258083, 8278373, and 8361934; U.S. Patent Application Publications numbered 20110311719, 20110312859, 201203254743, 20120202719 and 20130096037; and other patents pending.
- Prospective customers are encouraged to review the following recent Society of Petroleum Engineers (SPE) papers on ULW proppants: SPE 116057 (2008), SPE 119385 (2009), SPE 124767 (2009), SPE 138319 (2010), SPE 146447 (2011 Gravel Pack), and SPE 181849 (2016).

Packaging and Delivery: Available in 2000 pound super sacks FOB Belle Chasse, Louisiana.

BASELINE FRACTURE CONDUCTIVITY MEASUREMENT PROCEDURES

Less than a full layer of 14/16 U.S. mesh size [diameters ranging from 0.0469 to 0.0555 inches (1.19 to 1.41 mm)] FracBlack HT™ beads were used at a loading of 0.02 lb/ft^2 (0.09765 kg/m^2) in Ohio sandstone. Deoxygenated silica-saturated 2% potassium chloride (KCl) brine of pH 7 was used as the test fluid. (It had been established, in previous experiments using FracBlack™ that very similar results are obtained if crude oil is used as the test fluid.) A test was started at a temperature of 121.1°C (250°F), under a closure stress of 41.37 MPa (6000 psi). The closure stress was increased to 48.26 MPa (7000 psi) after 517 hours and to 55.16 MPa (8000 psi) after 829 hours while keeping the temperature at 250°F. The temperature was increased to 135°C (275°F) after 1164 hours while keeping the closure stress at 8000 psi.

Testing procedures described in 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) were used, except for the following variances:

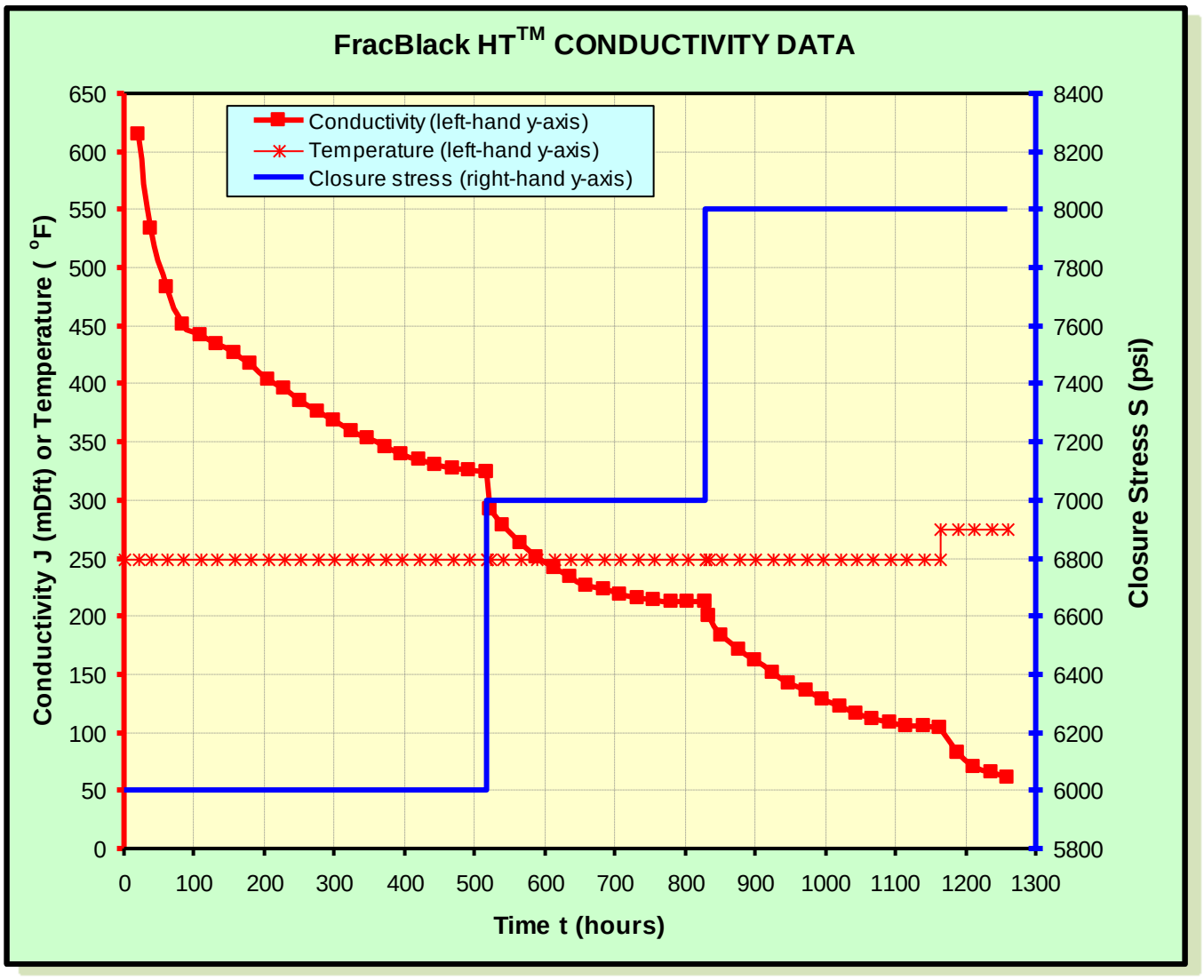
1. Section 10.2.3 refers to a method for pouring the proppant into the test cell. By contrast, for partial monolayers, the proppant was placed manually, approximately evenly over the rock face.
2. Section 12 specifies 50 hour stress periods ramping by 2000 psi intervals. By contrast, in obtaining the long-term conductivity data reported on the next page, the conductivity was measured at each stress level (6000, 7000, and 8000 psi; and thus with an interval of 1000 psi) for hundreds of hours.
3. Furthermore, at the end of the test, the temperature was ramped from 250°F to 275°F at a stress level of 8000 psi and the conductivity was also measured at this higher temperature for 96 hours.

RESISTANCE TO MIGRATION

The migration resistance of beads of our earliest product, FracBlack™, had been established in previous work. These experiments, which are summarized in this paragraph, were not repeated for FracBlack HT™ beads. Sparse layers 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 sparse loading with a narrow bead size distribution provides the maximum benefit in terms of width retention, porosity retention and stability.

BASELINE FRACTURE CONDUCTIVITY DATA

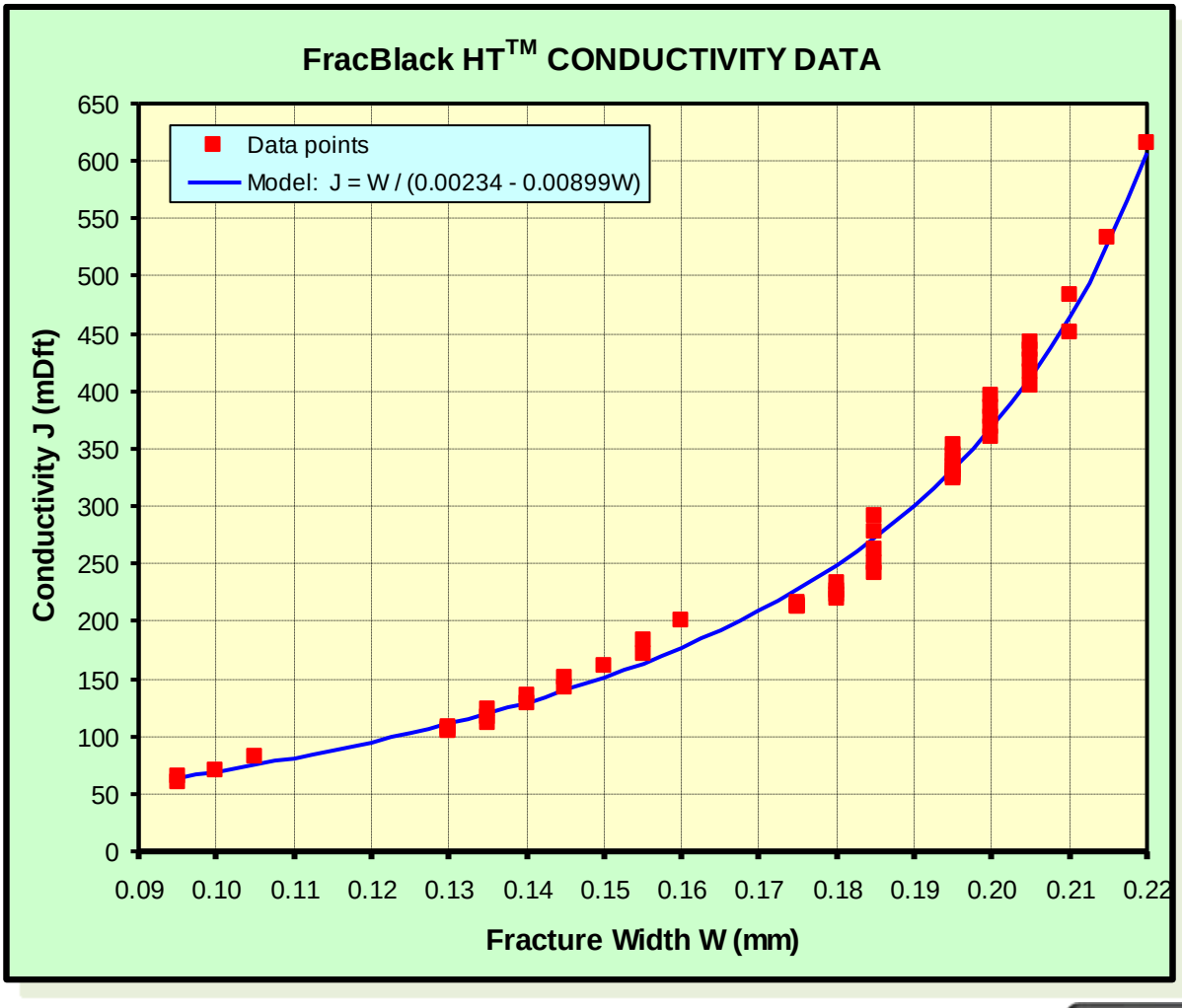
To simulate a far field application, 14/16 U.S. mesh size beads of FracBlack HT™ were used at a loading of 0.02 lb/ft^2 on Ohio sandstone in a long-term conductivity test. A test was started at a temperature of 121.1°C (250°F), under a closure stress of 41.37 MPa (6000 psi) which was increased to 48.26 MPa (7000 psi) after 517 hours and to 55.16 MPa (8000 psi) after 829 hours, keeping the temperature at 250°F. The temperature was increased to 135°C (275°F) after 1164 hours while keeping the closure stress at 8000 psi.



RELATION BETWEEN CONDUCTIVITY AND FRACTURE WIDTH

It is shown below that FracBlack HT™ owes its ability to allow the flow of liquids for prolonged periods under demanding test conditions to the fact that the material keeps a fracture propped open for prolonged periods under such conditions. The conductivity data obtained at 250°F under 6000 psi, 7000 psi and 8000 psi; and at 275°C under 8000 psi, which were shown on Page 3 of this Product Bulletin, can all be described with a simple two-parameter empirical equation where J is in mDft and W is in millimeters (mm):

$$J = \frac{W}{(0.00234 - 0.00899W)}$$

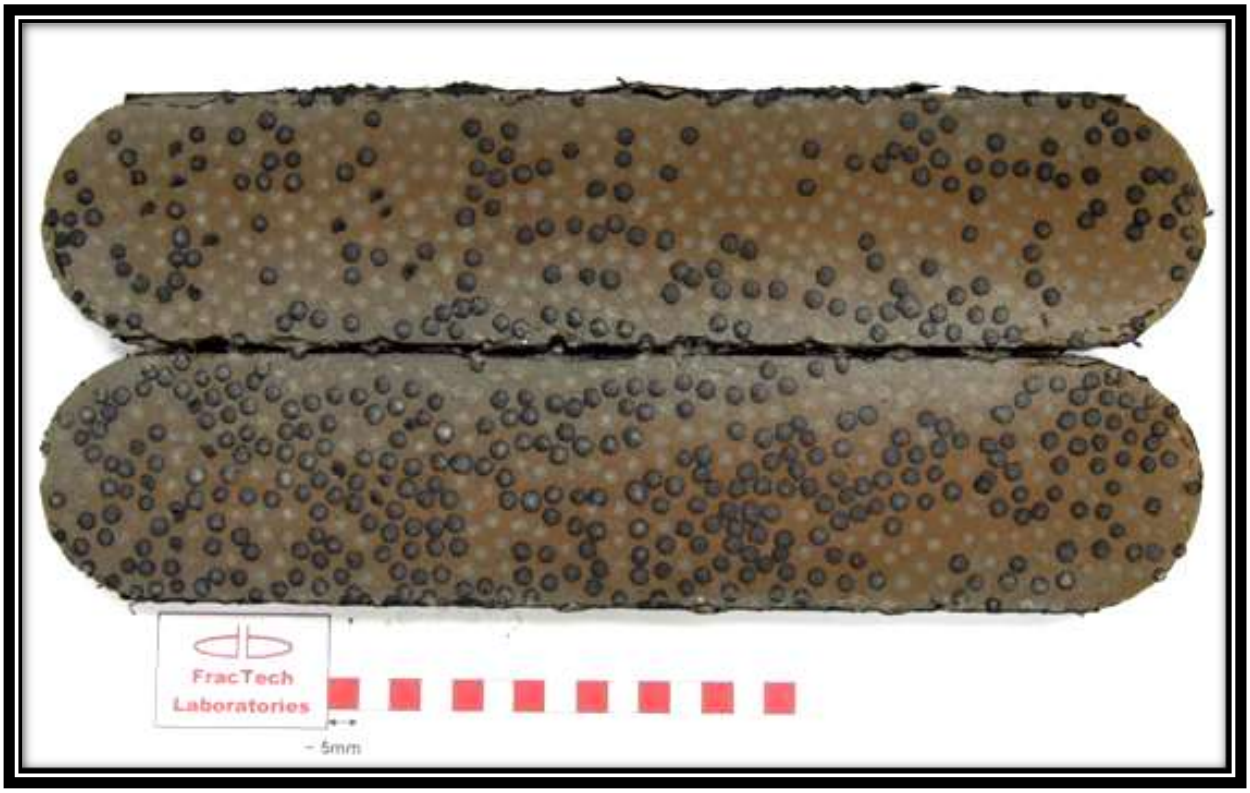


PHOTOGRAPH OF DRY BEADS OF FRACBLACK™

The photograph below shows some "dry" beads of FracBlack™. The very high sphericity and roundness of the beads can be seen readily by visual inspection.

PHOTOGRAPH OF POST-TEST FRACBLACK HT™

The photograph shown below was taken after the completion of the conductivity test. Note that the FracBlack HT™ is essentially intact as a result of the beads being somewhat flattened but without the generation of fines via brittle fracture.



CYCLIC LOADING RESISTANCE

The cyclic loading resistance of beads of our earliest product, FracBlack™, had been shown in previous work. These experiments, which are summarized in this paragraph, were not repeated for FracBlack HT™ beads. 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) for FracBlack™, 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 CO_2 STIMULATION PROCEDURES

FracBlack™ is compatible with liquid CO_2 stimulation procedures. Testing indicated only a very small reduction, within the margin of error of the measurements, in the conductivity measurements consisting of beads that had been first soaked in liquid CO_2 under a pressure of 20 MPa (2900 psi) at a temperature of 104°C (220°F) for one hour. These experiments were not repeated for FracBlack HT™.

ISO 13503-2:2006 SPECIFICATIONS

Testing was carried out 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 for the earlier product grades (crush resistance for FracBlack HP™, other data for FracBlack™) are summarized below. The relevant section of ISO 13503-2:2006 is also indicated for each test.

TEST	SECTION	RESULT	COMMENTS
Crush Resistance		Minimal (0-05%) fines generation, as mass percentage going through a 40 U.S. mesh size screen, no breakage	Starting from 14/40 U.S. mesh size beads, measured under a load of 48.26 MPa (7000 psi) at 120°F dry API RP60
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	<0.5%	Measured by mass
Turbidity (FTU)	9	29	Measured using spectrophotometer
Bulk Density (g/cm^3)	10.3	0.66 ± 0.01	None
Absolute Density	10.5	1.054 ± 0.011	None

COMPATIBILITY WITH ACID STIMULATION PROCEDURES

FracBlack™ as part of the acid fracturing process offers an expansion of conductivity potential in an area that previously relied solely on etching and worm holes. FracBlack™ is virtually insoluble therefore an ideal proppant candidate for such an operation. With a specific gravity of around 1.06, FracBlack™ is easily placed in the acid without transportability issues. In addition, this near buoyant nature of FracBlack™ indicates gelled acid or viscous fluids do NOT need to be used for proppant transport thus no breaking of gels. Ultimately, this increases the fracture conductivity due to low skin damage.

Placing proppant in the far field areas of the fracture that would otherwise not be impacted by the spent acid provides additional conductivity for production and has the potential to significantly flatten the decline curve.

LOOKING FORWARD WITH ULTRA-LIGHTWEIGHT TECHNOLOGY

FracBlack™ technology is steadily increasing its presence in markets around the world for far field applications when used in conjunction with conventional proppants. Hundreds of successful applications have been completed in the United States, Russia, Romania, Columbia, China and Canada in both traditional and coal bed methane (CBM) projects. Outstanding performance as gravel pack material has also been documented for several major applications in South America. Additional applications in Europe indicate that ultra-lightweight technology will provide increased ability to recover hydrocarbons and improve reservoir value in the expanding shale and CBM projects worldwide.

Applications have expanded to include the addition of FracBlack™ as a critical supplement to sand in individual stages providing the operator with increased propped area beyond and above areas which can be reached by sand alone. This additional far field proppant placement helps operators provide the maximum conductivity for each stage and significantly improves the potential for flatter decline curves and greater value per well. FracBlack™ provides operators the ability to **"Prop What You Frac …"**

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