QUALIFYING FLUID & PROPPANT PERFORMANCE®

Hi-Crush Proppants, LLC

Kermit 100M

Prepared For:

John Turner

101-17-08-81-01

Thursday, August 10, 2017

●17222 Huffmeister Rd, Ste. B●Cypress, TX 77429-1643●Ph.: 888-756-2112●Fax: 281-256-8880●
●www.proptester.com●

Information:

Date:	**August 10, 2017**
Company Requesting:	**Hi-Crush Proppants, LLC**
Company Contact:	**John Turner**
Sales Contact:	**Brandon White**
Report Generated by:	**Brandon White**
Technician:	**Cayden Sessions**

Background:

A sample from Hi-Crush Proppants, LLC was delivered to the PropTester, Inc. laboratory in Cypress, TX from John Turner with Hi-Crush Proppants, LLC. The sample was labeled Kermit 100M. Instructions are to perform full API RP-19C analysis on this sample. All tests are completed according to API RP-19C standards.

Color Analysis – Proppant Test Data:

Proppant test results are referenced against API RP-19C standards and available public data. Classification by color or numerical variance does not imply a level of performance. However, coloring of standard and public data does indicate a specific range of variance of sample test results. The numerical ranges are typical of data variance between laboratories that participate in API/ISO round robin or performance (e.g. conductivity) evaluation. When limits (e.g. > or <) are used, then only green or red will apply.

Conclusions:

Kermit 100M

API RP-19C Analyses

Pass (green)	➢ Does sample meet API RP-19C requirements for commercial grade fracturing proppant?
Pass (green)	➢ **Turbidity** - Does sample meet API RP-19C requirements for fracturing proppant?
Pass (green)	➢ **Roundness & Sphericity** - Does sample meet API RP-19C Krumbein shape requirements?
Pass (green)	➢ **Particle Distribution** -Does sample meet API RP-19C requirements for particle distribution?
Pass (green)	➢ **Acid Solubility** - Does sample meet API RP-19C "12:3 HCl/HF" Acid Solubility standards?
	➢ **K-factor:** 11K

PropTester Resin Coated Analyses

Not Tested	➢ **UCS:** psi	Not Tested	➢ **% Loss on Ignition (LOI)**
Not Tested	➢ **Wettability**	Not Tested	➢ **Coating Efficiency**

Green: **Sample meets or passes requirements** **Red:** **Sample fails to meet requirements.**

Comments:

*** Refer to test definitions and descriptions for more information on each critical property. ***

Figure 1: Proppant Test Data - Kermit 100M

Quick Chek ✓			API RP-19C	Kermit 100M
Turbidity (NTU)			≤ 250	115
Krumbein Shape Factors				
Roundness			≥ 0.6	0.7
Sphericity			≥ 0.6	0.8
Bulk Density (g/cc)				1.49
Bulk Density (lb/ft^3)				92.93
Specific Gravity (Apparent Density)				2.65
Particle Size Distribution, mm		Sieve		
	0.425	40	≤ 0.1	0.0
	0.300	50		0.4
	0.250	60		10.8
	0.212	70		21.4
	0.180	80		23.7
	0.150	100		19.6
	0.125	120		14.3
	0.106	140		5.4
	0.075	200		3.6
	<0.075	Pan	≤ 1.0	0.8
		Total		100.0
		% In Size	≥ 90	95.1
Mean Particle Diameter, mm				0.189
Median Particle Diameter (MPD), mm				0.181
Solubility in12/3 HCl/HF for 0.5 HR @ 150°F (% Weight Loss)			≤ 3.0	2.9
Crush Chek✓				
API Crush Analysis (% Fines) 4lb/ft2@ 11,000 psi			≤ 10	7.9
API Crush Analysis (% Fines) 4lb/ft2@ 12,000 psi			≤ 10	10.6

Meets API RP-19C standards

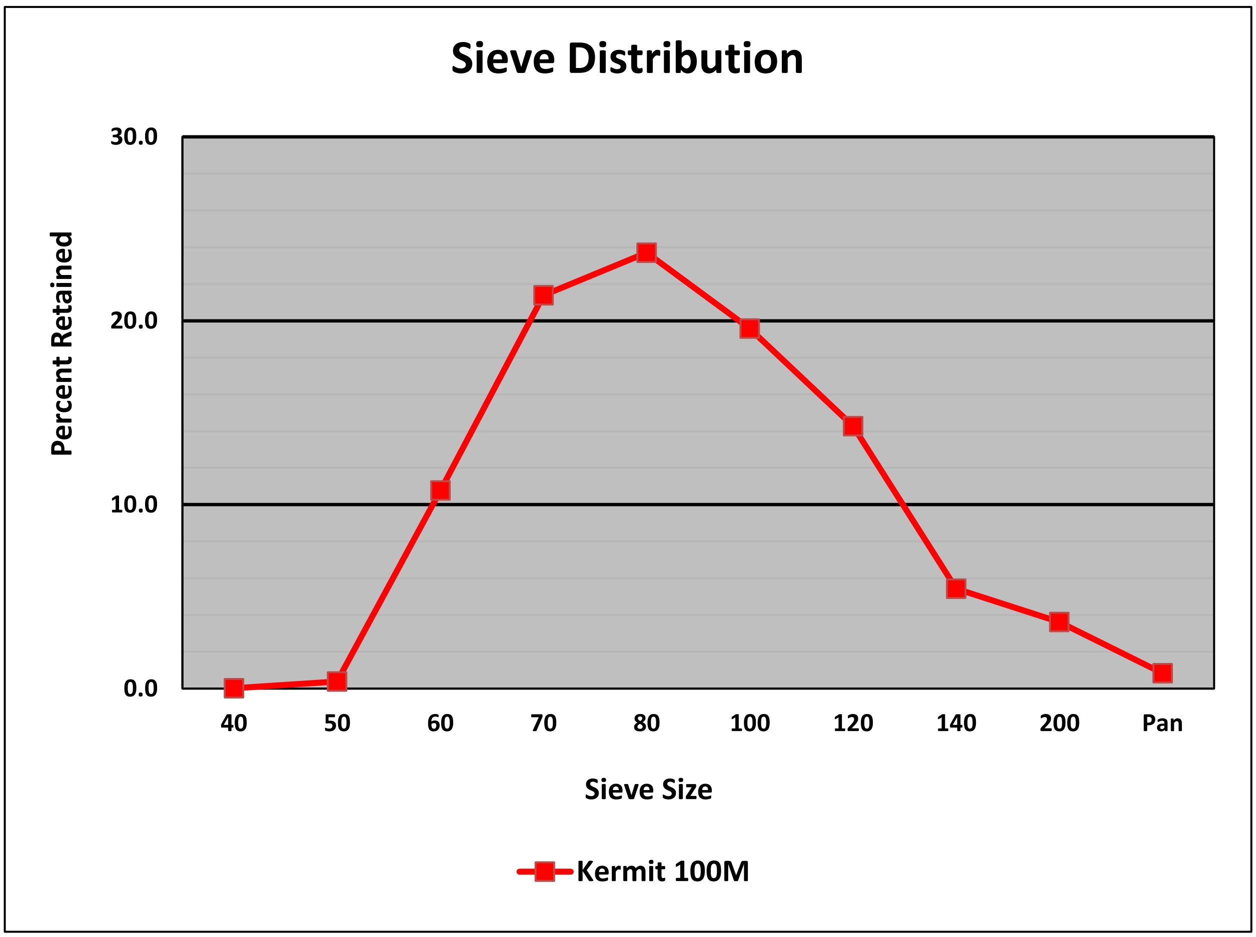
Fails API RP-19C standards

Figure 2: Particle Distribution Graph

Kermit 100M

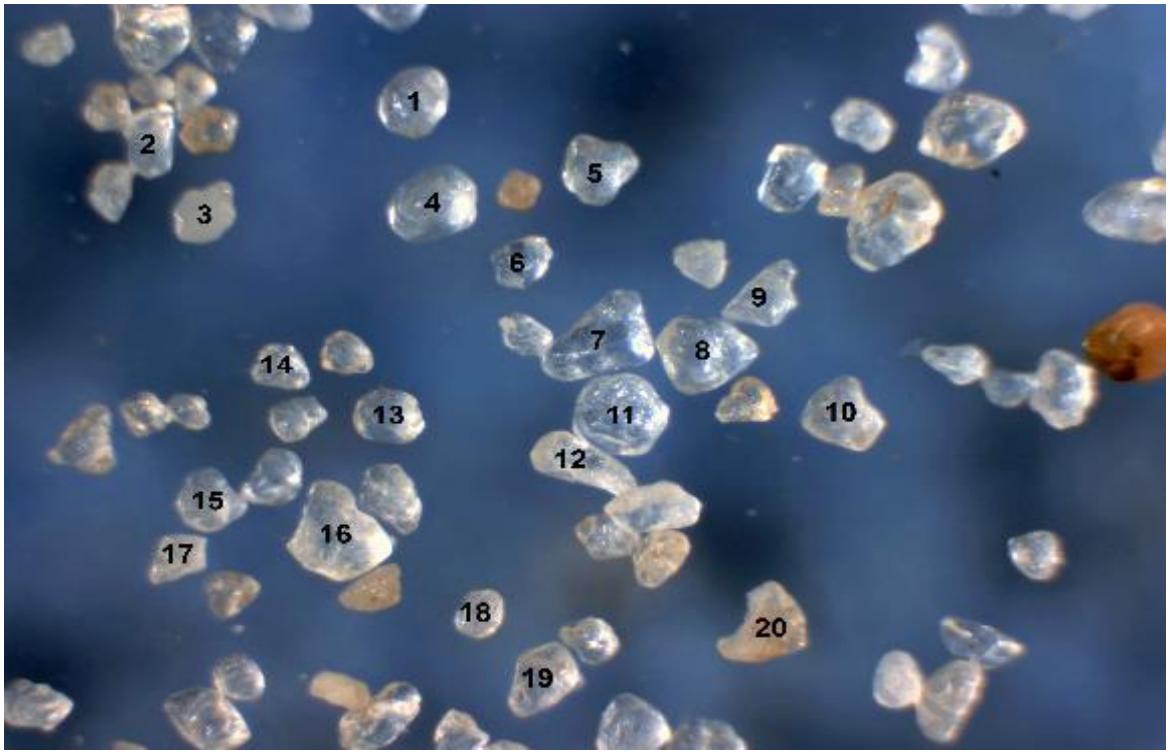
Median : 0.181 mm **Mean :** 0.189 mm

Mesh Size (mm)	Sieve #	Kermit 100M
0.425	40	0.0
0.300	50	0.4
0.250	60	10.8
0.212	70	21.4
0.180	80	23.7
0.150	100	19.6
0.125	120	14.3
0.106	140	5.4
0.075	200	3.6
<0.075	Pan	0.8



Photomicrograph 1

100X Magnification



Testing Definitions & Descriptions

Turbidity – A measure to determine the levels of dust, silt, suspended clay, or finely divided inorganic matter levels in fracturing proppants. High turbidity reflects improper proppant manufacturing and/or handling practices. The more often and more aggressively a proppant is handled, the higher the turbidity. Offloading pressures exceeding manufacturer guidelines can have a detrimental effect on the proppant performance. Produced dust can consume oxidative breakers, alter fracturing fluid pH, and/or interfere with crosslinker mechanisms. As a result, higher chemical loadings may be required to control fracturing fluid rheological properties and performance. If fluid rheology is altered, then designed or modeled fracture geometry and conductivity will be altered. A change in conductivity directly correlates to reservoir flow rate.

Krumbein Shape Factors – determines proppant roundness and sphericity. Grain roundness is a measure of the relative sharpness of grain corners, or of grain curvature. Particle sphericity is a measure of how closely a proppant particle approaches the shape of a sphere. Charts developed by Krumbein and Sloss in 1963 are the most widely used method of determining shape factors.

Clusters – Proppant grains should consist of single, well-rounded particles. During the mining and manufacturing process of proppants, grains can attach to one another causing a cluster. It is recommended by API RP-19C that clusters be limited to less than 1% to be considered suitable for fracturing proppants.

Bulk Density – A dry test to gain an estimation of the weight of proppant that will fill a unit volume, and includes both proppant and porosity void volume. This is used to determine the weight of a proppant needed to fill a fracture or a storage tank.

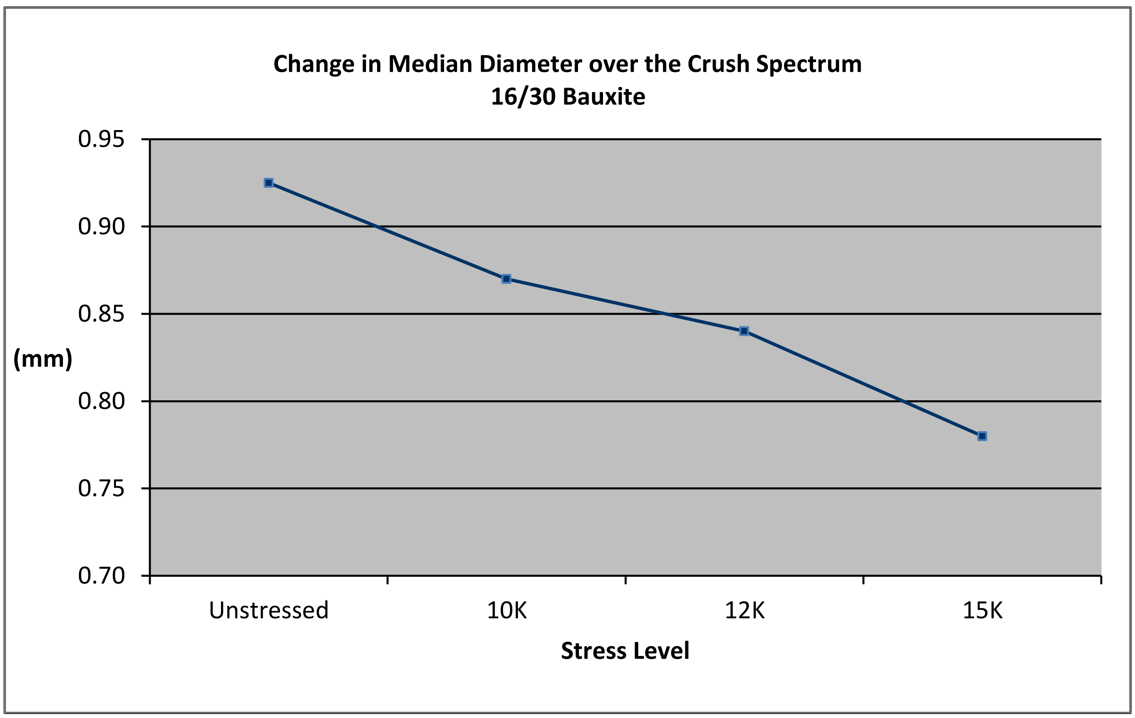
Specific Gravity – Also called Apparent Density, it includes internal porosity of a particle as part of its volume. It is measured with a low viscosity fluid that wets the particle surface.

Sieve Analysis: Particle Size Distribution & Median Particle Diameter – Also called a sieve analysis, this test determines the particle size distribution of a proppant sample. Calibrated sieves are stacked according to API RP-19C recommended practices and loaded with a pre-measured amount of proppant. The stack is placed in a Ro-Tap sieve shaker for 10 minutes and then the amount on each sieve is measured and a percent by weight is calculated on each sieve. A minimum of 90 % of the tested proppant sample should fall between the designated sieve sizes. Not over 0.1% of the total tested sample should be larger than the first sieve size and not over 1.0% should fall on the pan. The in-size percent, mean particle diameter, and median particle diameter are calculated which relates directly to propped fracture flow capacity and reservoir productivity.

Testing Definitions & Descriptions

API / ISO Crush Test – The **API** test is useful for comparing proppant crush resistance and overall strength under varying stresses. A proppant is exposed to varying stress levels and the amount of fines is calculated and compared to manufacturer specifications. Studies by Coulter & Wells (e.g. SPE JPT, June 1972, pp. 643-650) have demonstrated that as little as 5% added fines can reduce propped fracture conductivity by 50%. The API test classifies a proppant according to the stress at which ≤ 10% fines is generated; for example an API 7k proppant would produce ≤ 10% fines at 7000 psi.

A **PT Crush Profile** (see example below) can show graphically how median particle diameter (MPD) can vary with changes in closure stress. Unlike the API crush test, the PT Crush Profile uses the entire proppant sample for crushing at each stress, the sample is then sieved to determine particle distribution, and MPD is then calculated. A change in MPD directly correlates to flow capacity and reservoir productivity. *This test, ordered separately, provides a more realistic view of initial proppant flow capacity at reservoir specific stresses.*



Testing Definitions & Descriptions

Acid Solubility – The solubility of a proppant in 12-3 hydrochloric-hydrofluoric acid (HCl-HF) is an indication of the amount of undesirable contaminates. Exposing a proppant (specifically gravel pack/frac pack materials) may result in dissolution of part of the proppant, deterioration in propping capabilities, and a reduction in fracture conductivity in the zone contacted by such acid. The loss of fracture conductivity near the wellbore may cause a dramatic reduction in well productivity, as has been demonstrated by Raymond and Binder (JPT, January 1967, Pgs. 120-130).

Resin Content/Loss on Ignition (LOI) – This test determines the resin content remaining on the proppant. Resin content is a direct function of the proppants strength and its ability to encapsulate the substrate when exposed to high stress levels. By reducing fines generation and migration, the proppant pack remains clean, allowing maximum well production.

Resin Coating Efficiency – Used to determine the percent of uncoated grains in a resin coated proppant sample.

Unconfined Compressive Strength (UCS) – Grain-to-grain bonding at specific temperatures over time will develop bond strength that can be measured by using a UCS test. This test directly reflects the proppants ability to bond downhole in order to reduce embedment and control proppant flowback. By reducing embedment and keeping the available proppant in place, fracture width can be maximized.

pH of Water Extract – This test reflects the potential chemical impact of a proppant on fracturing fluid pH. Processing or manufacturing of a proppant can leave residues, or ‘free phenol’ in the case of resin coated proppants, which can interfere with polymer hydration rates, cross-linking mechanisms, etc. These effects if detected can usually be remedied by increasing buffering capacity, but if undetected can alter fracturing fluid rheology, change fracture geometry, and impact propped fracture conductivity. A change in conductivity directly correlates to reservoir production rate.

TEST PROCEDURES

***PropTester*®** & API test procedures were applied in this Request for Analysis (**RFA**)

Quick Chek	**Procedures**
Turbidity	***API RP-19C***
Microscopic Exam	***API RP-19C***
Krumbein Shape Factors	
Clusters	
Photomicrographs	
Bulk Density	***API RP-19C***
Specific Gravity	***API RP-19C***
Sieve Analysis	***API RP-19C***
Particle Size Distribution	***API RP-19C***
Mean Particle Diameter	***API RP-19C***
Median Particle Diameter	***Prop Tester*®**

Crush Chek	**Procedures**
Old API Crush Test	**API RP 56/58/60**
Current API Crush Test	***API RP-19C***
PT Crush Profile	***Prop Tester*®**

Res Chek	**Procedures**
% Resin Content, LOI	***Prop Tester*®**
Coating Efficiency %	***Prop Tester*®**
Unconfined Compressive Strength (UCS)	***Prop Tester*®**
pH of Water Extract	***Prop Tester*®**

DISCLAIMER

PROPTESTER MAKES NO WARRANTY OR REPRESENTATION (EXPRESS OR IMPLIED) CONCERNING THE PRODUCT, ITS MERCHANTABILITY, ITS FITNESS FOR ANY PURPOSE OR USE, OR FOR ACCURACY OR COMPLETENESS OF ANY INFORMATION BY THE SELLER OR MANUFACTURER. IT IS THE RESPONSIBILITY OF THE USER OF THE PRODUCT TO INVESTIGATE AND UNDERSTAND ALL PERTINENT SOURCES OF INFORMATION AND TO COMPLY WITH ALL LAWS, REGULATIONS AND PROCEDURES APPLICABLE TO THE SAFE HANDLING, USE AND DISPOSAL OF THE PRODUCT AND TO DETERMINE THE SUITABILITY OF THE PRODUCT FOR ITS INTENDED USE. THIS REPORT IS LIMITED TO ONLY THOSE TESTS REQUESTED AND PERFORMED ON THE INDICATED SAMPLE. NO CLAIM OF DAMAGES OF ANY KIND, WHETHER AS TO PRODUCT DELIVERED, FOR NON-DELIVERY OF PRODUCT OR USE OF PRODUCT AND WHETHER BASED ON CONTRACT, BREACH OF WARRANTY, BREACH OF REPRESENTATIONS, NEGLIGENCE, STATUTES OR OTHERWISE SHALL BE GREATER THAN THE COST OF THE TEST, PROCEDURES, OR ANALYSIS COVERED BY THIS REPORT. IN NO EVENT SHALL PROPTESTER BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, EVEN IF THE CLAIM IS BASED ON CONTRACT, BREACH OF WARRANTY REPRESENTATION, NEGLIGENCE, STATUES OR OTHERWISE.