QUALIFYING FLUID & PROPPANT PERFORMANCE®

20/40

Prepared For:

Tad Moats

101-21-07-97-10

Thursday, August 12, 2021

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●www.proptester.com●

Information:

Date:	**August 12, 2021**
Company Requesting:	**HI Crush**
Company Contact:	**Tad Moats**
Sample Origin:	**UPS: 1Z7787X80399969450**
Sales Contact:	**Ashley Rich**
Report Generated by:	**David Stewart**
Technician:	**Bryan Drebon**

Background:

A sample from HI Crush was delivered to the PropTester, Inc. laboratory in Cypress, TX from Tad Moats on 7/30/2021. The sample was labeled 20/40. Instructions are to perform Full API STD 19C on this sample. All tests are completed according to API STD-19C standards.

Conclusions:

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API STD-19C Analyses

- Does sample meet API STD-19C requirements for commercial grade fracturing proppant?
- **Turbidity** - Does sample meet API STD-19C requirements for fracturing proppant?
- **Roundness & Sphericity** - Does sample meet API STD-19C Krumbein shape requirements?
- **Particle Distribution** -Does sample meet API STD-19C requirements for particle distribution?
- **Acid Solubility** - Does sample meet API STD-19C "12:3 HCl/HF" Acid Solubility standards?
- **K-factor:** 6K

Comments:

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

Figure 1: Proppant Test Data - 20/40

Quick Chek ✓			API STD-19C	20/40
Turbidity (NTU)			≤ 250	20
Krumbein Shape Factors				
Roundness			≥ 0.6	0.9
Sphericity			≥ 0.6	0.9
Bulk Density (g/cc)				1.57
Bulk Density (lb/ft^3)				97.99
Specific Gravity (Apparent Density)				2.66
Particle Size Distribution, mm		Sieve		
	1.180	16	≤ 0.1	0.0
	0.850	20		4.6
	0.710	25		19.7
	0.600	30		35.8
	0.500	35		28.5
	0.425	40		6.1
	0.300	50		4.5
	<0.300	Pan	≤ 1.0	0.9
	Total			100.0
	% In Size		≥ 90	90.1
Mean Particle Diameter, mm				0.630
Median Particle Diameter (MPD), mm				0.607
Solubility in12/3 HCl/HF for 0.5 HR @ 150°F (% Weight Loss)			≤ 2.0	0.1
Crush Chek✓				
API Crush Analysis (% Fines) 4lb/ft2@ 6,000 psi			≤ 10	7.4
API Crush Analysis (% Fines) 4lb/ft2@ 7,000 psi			≤ 10	10.8

Meets API STD-19C standards

Fails API STD-19C standards

Figure 2: Particle Distribution Graph

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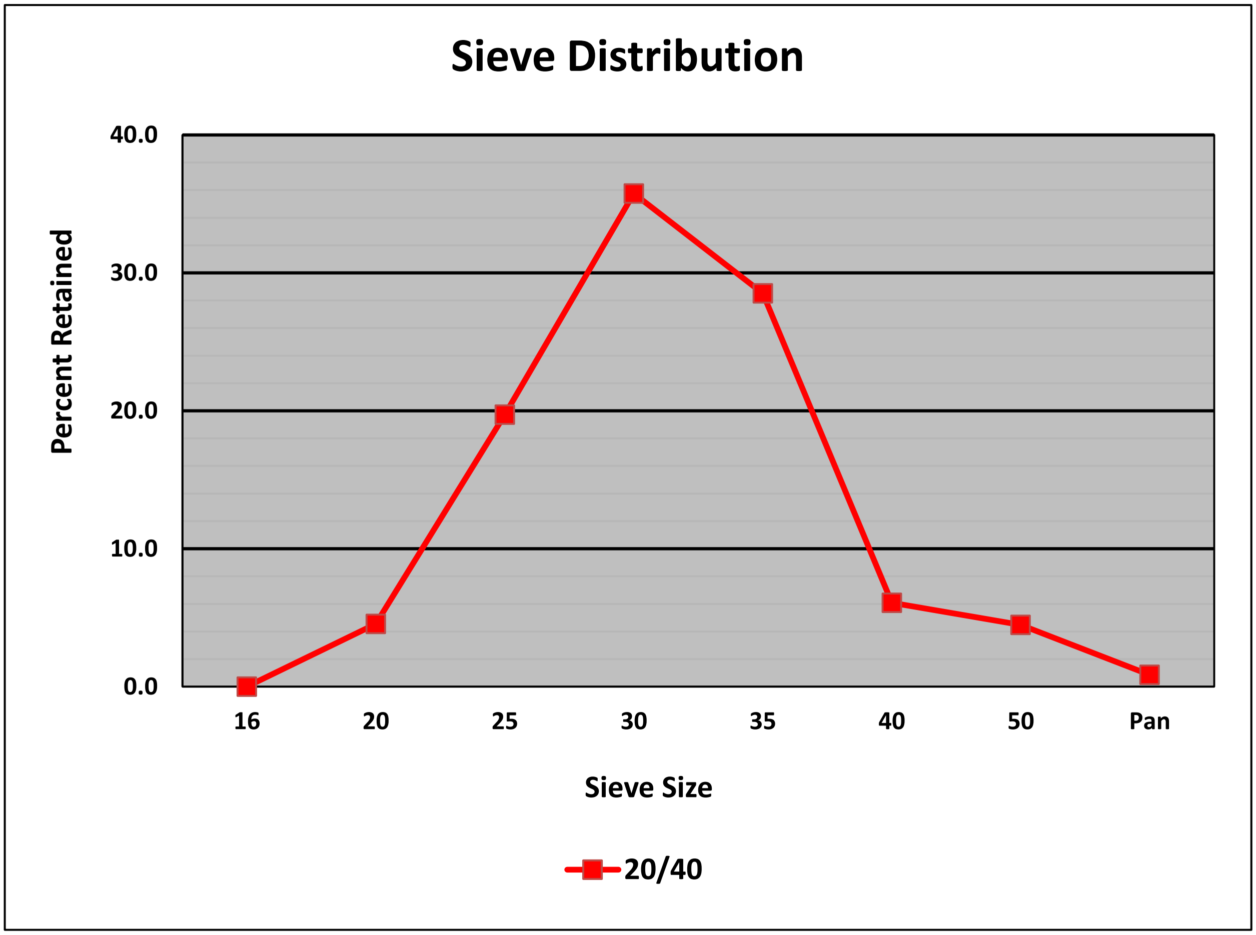
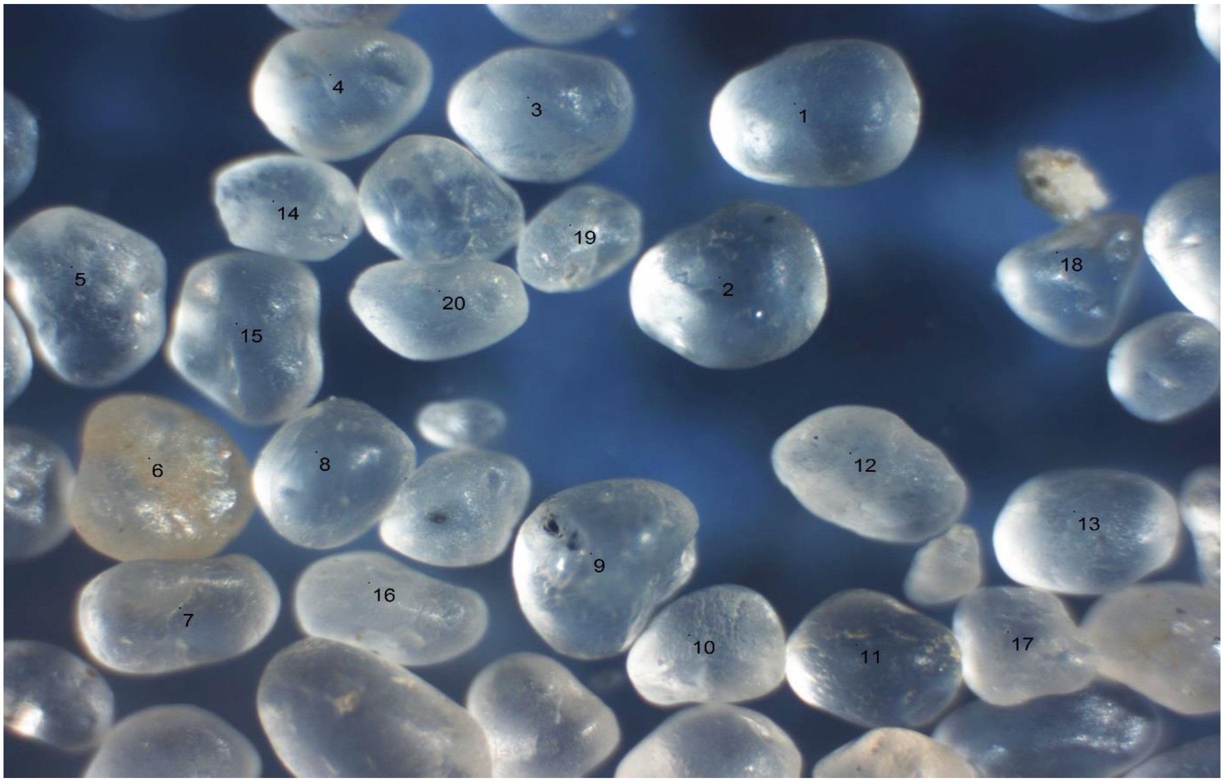
Median : 0.607 mm **Mean :** 0.630 mm

Mesh Size (mm)	Sieve #	20/40
1.180	16	0.0
0.850	20	4.6
0.710	25	19.7
0.600	30	35.8
0.500	35	28.5
0.425	40	6.1
0.300	50	4.5
<0.300	Pan	0.9



Photomicrograph 1

40X 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.

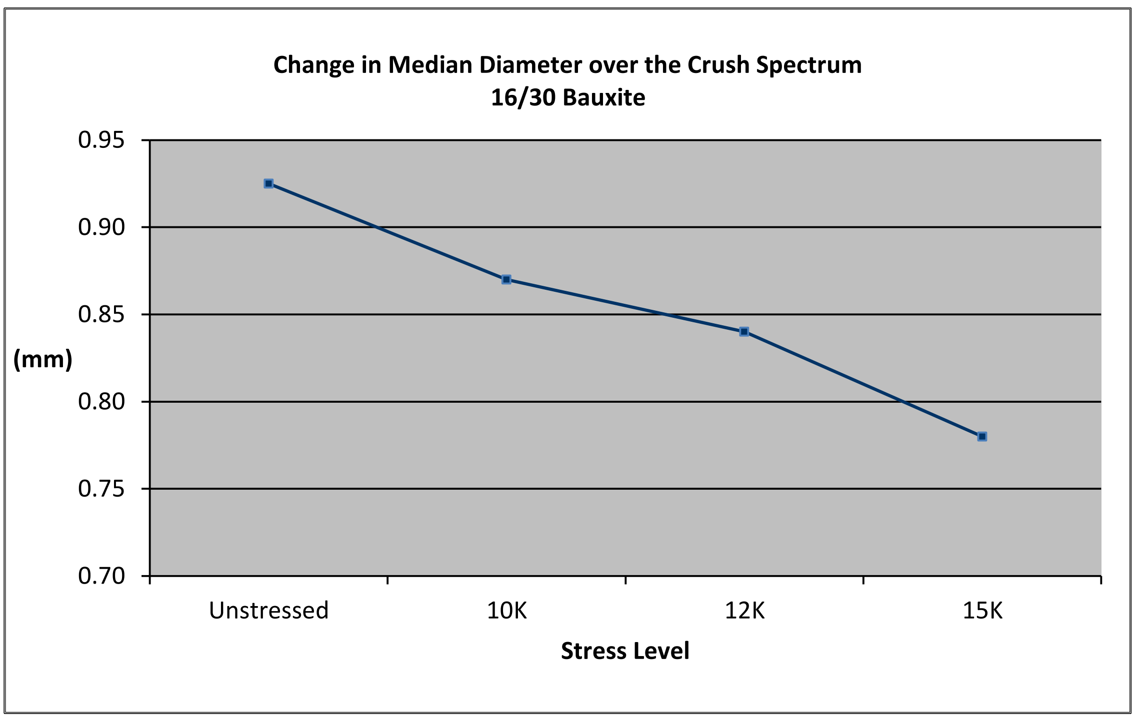
Specific Gravity – Also called Apparent Density, it includes internal porosity of a particle as part of its volume. It is measured with a low viscosity fluid that wets the particle surface.

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

Crush Chek	**Procedures**
Old API Crush Test	**API RP 56/58/60**
Current API Crush Test	***API STD-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*** ®


Qualifying Performance™
RIGHT Material
RIGHT Properties
RIGHT Conductivity
RIGHT Well Production