



Qualifying Fluid & Proppant Performance[®]

Pro Sands, LLC
Mr. Brennan Thomas

ISO Analysis

40/70 Sand

RFA #100-11-10-13-17

October 11, 2011



Information

Sample Origin:	Fed Ex
Sales Contact:	Brandon White
Report Generated by:	Kirk Decker
Technician:	Brandon White

Pre Job Background:

October 11, 2011 one raw sand sample originating from **Pro Sands** was delivered Fed Ex to PropTester's Cypress, TX Laboratory from Mr. Brennan Thomas, Pro Sands. The raw sand sample is sieved and Mr. Wilkett requests full **ISO Analysis 13503-2** analysis on the "**40/70 Sand**" sample following review of the raw sample Particle Size Distribution. **Figure 1**

Color Analysis – Proppant Test Data:

Proppant test results are referenced against ISO 13503-2 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 ISO round robin or performance (e.g. conductivity) evaluation. When limits (e.g. > or <) are used, then only green or red will apply.



Conclusions / Comments:

- The **Pro Sands 40/70 Sand** sample meets all **ISO 13503-2** Standard requirements for commercial grade 40/70 mesh sand fracturing proppant. **Figure 2 & Photomicrograph 1**
- The ISO Standard requirement is $\leq 3.0\%$ **Acid Solubility** by weight in 12/3 HCL/HF for 40/70 mesh sand. **Pro Sands 40/70 Sand** sand sample at 1.5% solubility in this acid and meets ISO Standards. **Figure 2**
- The **Pro Sands 40/70 Sand** sample meets the **ISO Standard** requirement of $\geq 90\%$ material falling between the 40 and 70 mesh screens with **Median Particle Diameters (MPD)** of 0.317 mm. The sample sieve distribution varies from that of 40/70 sand proppant public data as it is of a finer gradient. **Figures 2 & 3**
- The **ISO Crush** requires that crush properties of a proppant are evaluated at incremental pressures until fines generated are $\leq 10\%$ by weight. For **Pro Sands 40/70 Sand** sample crush test was halted at 6,000 psi when the sample produced an average of 9.4% fines by weight. According to ISO 13503-2, this sample is classified as ISO “6k” proppant. **Figure 2**
- **pH of Water Extract** test measures the pH influence of proppant to ensure compatibility with frac fluid systems. The pH of this proppant sample in water at pH = 8.47 shows very little change and is benign if representative. This **Pro Sands 40/70 Sand** proppant should not impact frac fluid chemistry. **Figure 2**



Figure 1- Sieve Distribution: Pro Sands – Raw Sand As Received

Median Particle Diameter		0.328 mm	
Mesh Distribution Mesh Size	Grams by Weight	% Retained by Weight	% Cumulative
6	0.00	0.0	0.0
8	0.00	0.0	0.0
10	0.00	0.0	0.0
12	0.00	0.0	0.0
14	0.00	0.0	0.0
16	0.05	0.0	0.0
18	0.00	0.0	0.0
20	0.00	0.0	0.0
25	0.00	0.0	0.0
30	0.00	0.0	0.0
35	0.57	0.6	0.6
40	8.30	8.2	8.8
45	26.94	26.7	35.5
50	31.29	31.0	66.5
60	26.50	26.2	92.7
70	6.10	6.0	98.8
80	1.12	1.1	99.9
100	0.09	0.1	100.0
120	0.00	0.0	100.0
140	0.00	0.0	100.0
200	0.01	0.0	100.0
pan	0.01	0.0	100.0
Total	100.98	100.0	
%16/30	0.0		
%20/40	8.8		
%30/50	66.4		
%30/60	92.7		
%30/70	98.7		
%40/70	89.9		
%50/140	33.5		
%70/140	1.2		



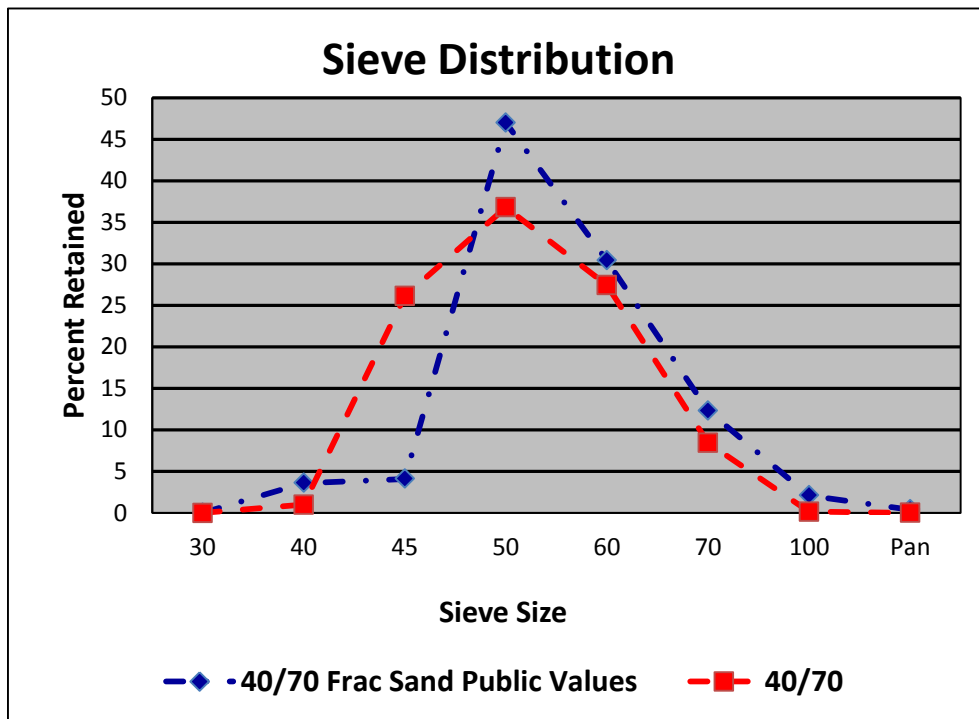
**Figure 2- Proppant Test Data:
Pro Sands - 40/70 Sand**

Quick Chek ✓		ISO 13503-2	40/70 Frac Sand Public Values	40/70	
Turbidity (NTU)		≤ 250	36	16	
Krumbein Shape Factors					
Roundness		≥ 0.6		0.7	
Sphericity		≥ 0.6		0.7	
Clusters (%)		≤ 1.0		0	
Bulk Density (g/cm ³)				1.40	
Bulk Density (lb/ft ³)				87.29	
Specific Gravity			2.65	2.61	
Particle Size Distribution, mm		Mesh size			
	0.600	30	≤ 0.1	0	0.0
	0.425	40		3.6	1.0
	0.355	45		4.1	26.1
	0.300	50		47.0	36.8
	0.250	60		30.4	27.4
	0.212	70		12.3	8.4
	0.150	100		2.1	0.2
	<0.150	Pan	≤ 1.0	0.4	0.0
	Total			100	100.0
	% In Size		≥ 90	93.8	98.8
Mean Particle Diameter, mm				0.323	
Median Particle Diameter (MPD), mm				0.317	
Solubility in 12/3 HCL/HF for 0.5 HR @ 150°F (% Weight Loss)		≤ 3.0	0.4	1.5	
pH of Water Extract – Test Fluid				7.78	
pH of Water Extract – Test Fluid & proppant				8.47	
Settling Rate (ft/min)				17.49	
Crush Chek ✓					
ISO Crush Analysis (% Fines) 4lb/ft ² @ 6,000 psi		≤ 10		9.40	
ISO Crush Analysis (% Fines) 4lb/ft ² @ 7,000 psi		≤ 10		12.99	
Sample Correlation 0 to +/- 8.999% Variance From ISO or Published Data		Sample Correlation +/- 9 to 25% Variance From ISO or Published Data		Sample Correlation -25 > X > +25% Variance From ISO or Published Data	

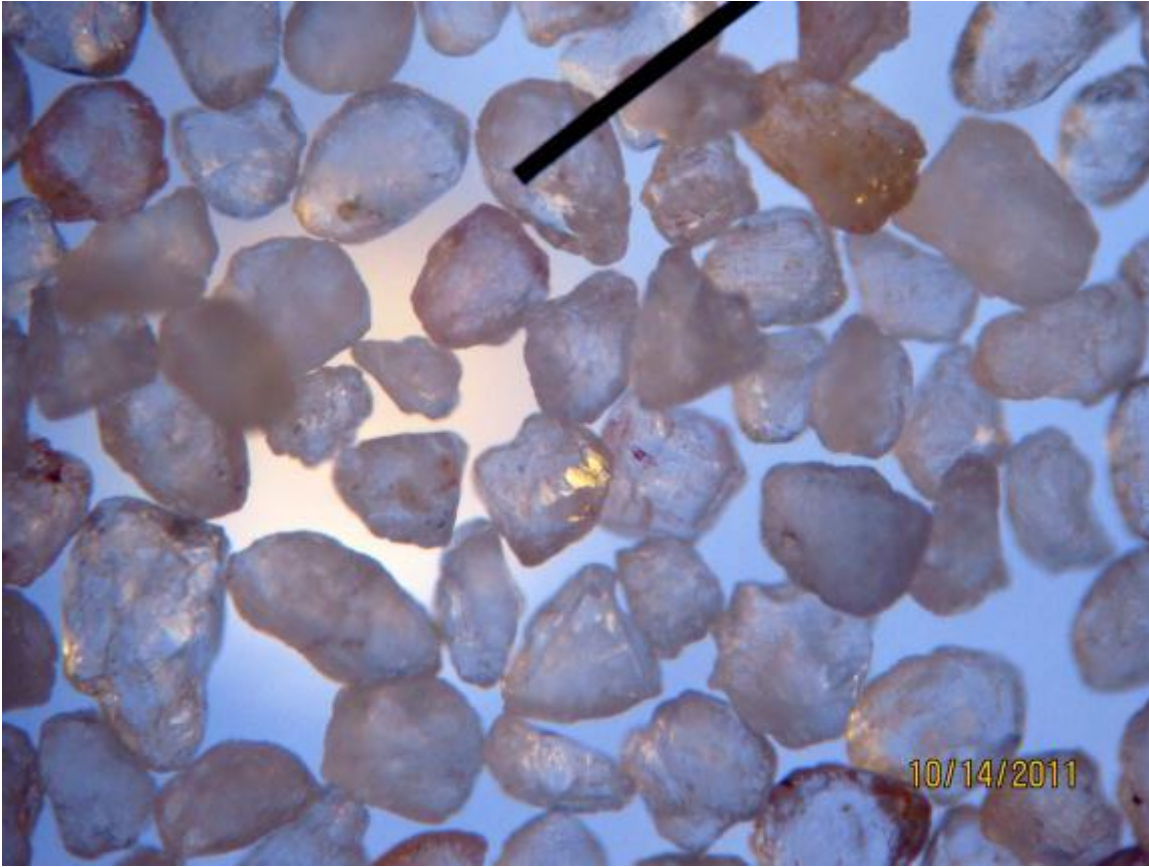


**Figure 3 - Sieve Distribution:
Pro Sands - 40/70 Sand**

Sieve Size	40/70 Frac Sand Public Values	40/70
30	0	0.0
40	3.6	1.0
45	4.1	26.1
50	47	36.8
60	30.4	27.4
70	12.3	8.4
100	2.1	0.2
Pan	0.4	0.0



Photomicrograph 1
Pro Sands - 40/70 Sand





Testing Definitions & Descriptions

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 ISO 13503-2 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 and MPD are calculated which relates directly to propped fracture flow capacity and reservoir productivity.

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 ISO 13503-2 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.

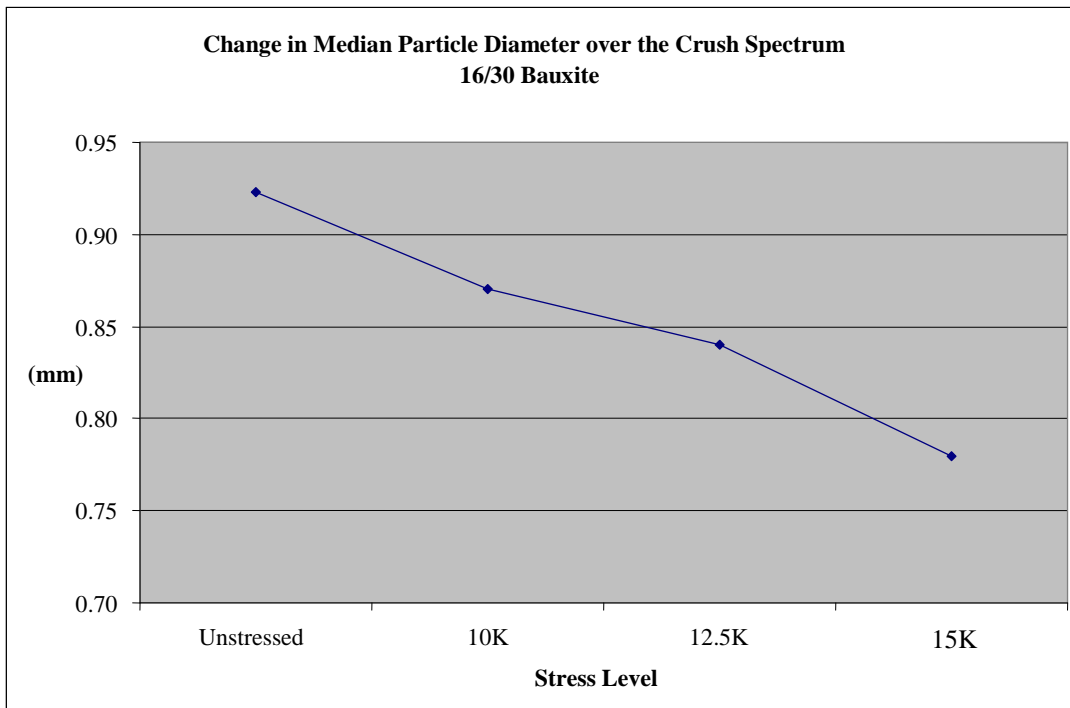
Specific Gravity – Also called Apparent Density, it includes internal porosity of a particle as part of its volume. It is measured with a low viscosity fluid that wets the particle surface.



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 ISO test classifies a proppant according to the stress at which $\leq 10\%$ fines are generated; for example an ISO 7k proppant would produce $\leq 10\%$ 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 ISO 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 contaminants. 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[®] & **ISO** test procedures were applied in this Request for Analysis (**RFA**)

Quick Chek ✓

Turbidity
Microscopic Exam
 Krumbein Shape Factors
 Clusters
 Photomicrographs
Bulk Density
Specific Gravity
Sieve Analysis
Particle Size Distribution
Mean Particle Diameter
Median Particle Diameter (MPD)

Procedures

ISO 13503-2

ISO 13503-2

ISO 13503-2

ISO 13503-2

ISO 13503-2

ISO 13503-2

ISO 13503-2

PropTester[®]

Crush Chek ✓

API Crush Test
ISO Crush Test
PT Crush Profile

Procedures

API RP 56/58/60

ISO 13503-2

PropTester[®]

Res Chek ✓

% Resin Content, LOI
Coating Efficiency %
Unconfined Compressive Strength (UCS)
pH of Water Extract

Procedures

PropTester[®]

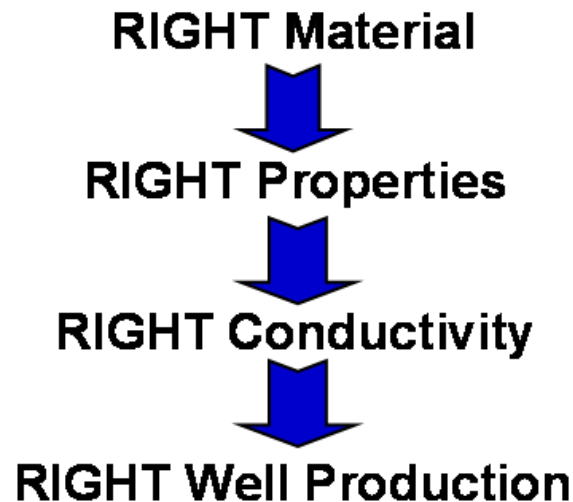
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Qualifying Performance™



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