



QUALIFYING FLUID & PROPPANT PERFORMANCE®

**Mississippi Sand
Mr. Curt Wilker**

ISO Conductivity Analysis

Mississippi 100 Mesh

RFA # 400-08-06-05-04

Friday June 13, 2008



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Background:

Fracture conductivity tests were performed on a sand sample labeled Mississippi 100 mesh. The test was performed at 150°F and 2,000-psi, 4,000-psi, 6,000-psi and 8,000-psi stress levels. International Standards Organization, ISO procedures 13305-5 “Procedures for measuring the long term conductivity of proppants” are used to obtain baseline values. Standard baseline testing is 50 hours at each stress level starting at 2,000 psi.

Samples:

The submitted Mississippi 100 mesh sand gave conductivity equal to a Northern white 100 mesh, with the MPD beginning at 0.158 inches and ending at 0.141 inches after the conductivity test.

➤ 70/140 Mississippi Sand

Procedures

A closure stress is applied across a test unit for 50 hours to allow the proppant sample bed to reach a semi-steady state condition. As the fluid is forced through the proppant bed, the pack width, differential pressure, temperature and flow rates are measured at each stress. Proppant pack permeability and conductivity are then calculated.

Multiple flow rates are used to verify the performance of the transducers, and to determine Darcy flow regime at each stress; an average of the data at these flow rates is reported. The test fluid is 2% potassium chloride filtered to 3µm absolute. The initial conductivity, permeability and width is measured and compared to the final conductivity, permeability and width after each stress period. Stress is applied and maintained using an Isco 260D. Stress is applied at 100 psi/minute.

Width of the proppant pack is determined by assembling the conductivity cell with the Ohio sandstone wafers and shims without the sample proppants. The distance between the width bars that are attached to each end of the conductivity cells are measured at each of the four corners and recorded. The cells are then disassembled and reassembled with the proppant samples. The measurements are made again at the beginning and ending of each stress period. Width is determined by subtracting the average of the zero from the average of each of the stress width values. Conductivity is calculated using Darcy’s equation.

Sieve analysis is performed using the procedure found in ISO 13503-2 “Measurements of proppants used in hydraulic fracturing and gravel pack operations” Standard US mesh screens are used to separate the sample by size. Not more than 0.1% should be greater than the first specified sieve and not more than 1% should be retained in the pan. There should be at least 90% retained in the specified screens.

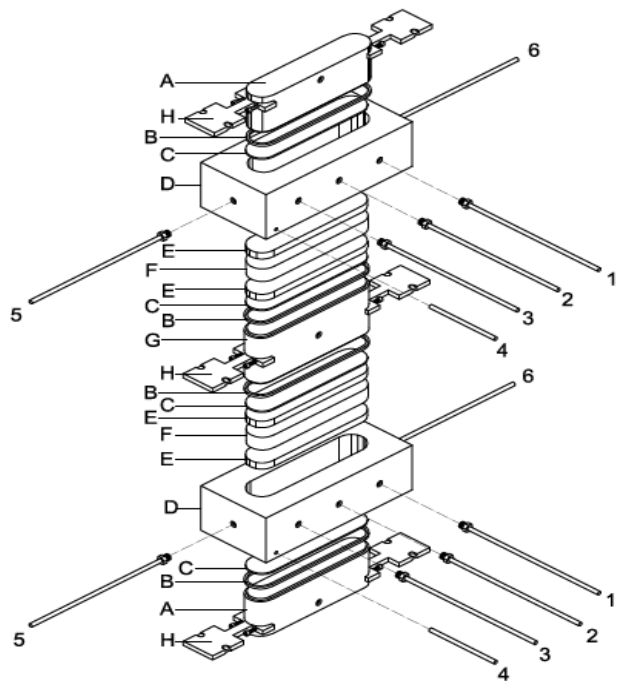
Calculations

Conductivity; $kW_f=26.78(\mu Q/\Delta P)^{-1}$

Permeability; $k=321.4\mu Q/(\Delta P)W_f^{-1}$

- k* is the proppant pack permeability, expressed in Darcy's;
- kW_f* is the proppant pack conductivity, expressed in millidarcy-feet
- μ* is the viscosity of the test liquid at test temperature, expressed in centipoises;
- Q* is the flowrate, expressed in cubic centimeters per minute;
- ΔP* is the differential pressure, expressed in psi;
- W_f* is proppant pack width, expressed in inches.

1-ISO 13503-5:2006(E) “Procedures for measuring the long term conductivity of proppants”



- 1. Low pressure port
- 2. Thermocouple
- 3. High pressure port
- 4. Not used
- 5. Inlet
- 6. Outlet
- A. Upper and lower piston
- B. Tetraseal
- C. Metal shim
- D. Cell body
- E. Ohio sandstone
- F. Proppant
- G. Center piston
- H. Width slots
- I. Set screws



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Table 1 – Baseline for Mississippi 100 Mesh

Stress (psi)	Conductivity (mDft)	Permeability (Darcy)	Width (in)
1000	444	25	0.218
2000	371	23	0.201
4000	144	10	0.173
6000	67	5	0.161
8000	25	2	0.154

Table 1: Baseline Results, 2lb/ft², 150°F, Ohio Sandstone after 50 hours continuous flow.

Table 2 – Sieve Analysis pre and post conductivity for Mississippi 100 Mesh

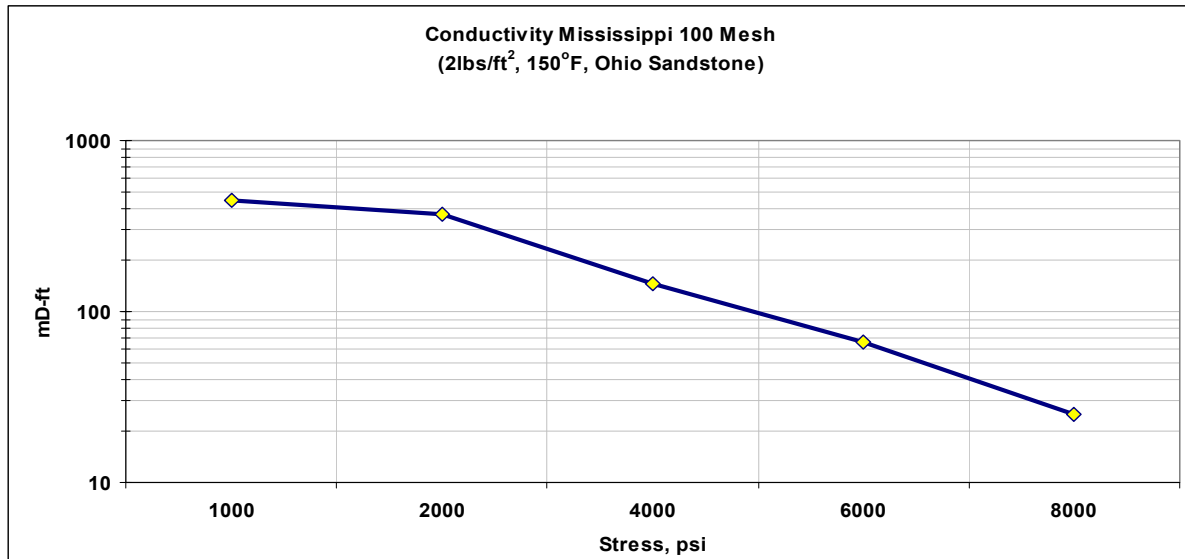
Quick Chek ✓		Published Data	Miss. Sand 100 mesh Before	Miss. Sand 100 mesh After
Particle Size Dist	Mesh size			
	16		0.00	0.00
	18		0.00	0.00
	20		0.00	0.00
	25		0.00	0.00
	30		0.00	0.00
	35		0.00	0.00
	40		0.00	0.00
	45		0.00	0.00
	50	≤ 0.1	0.00	0.00
	60		0.00	0.46
	70		1.61	1.45
	80		22.34	18.36
	100		39.98	30.61
	120		24.71	19.85
	140		10.81	10.52
	200		0.55	0.00
	PAN	< 1.0	0.00	18.77
	Total		100.00	100.00
	In-size (%)	≥ 90	97.84	79.33
	Median Particle Diameter (MPD in mms)		0.158	0.141



Mississippi Sand

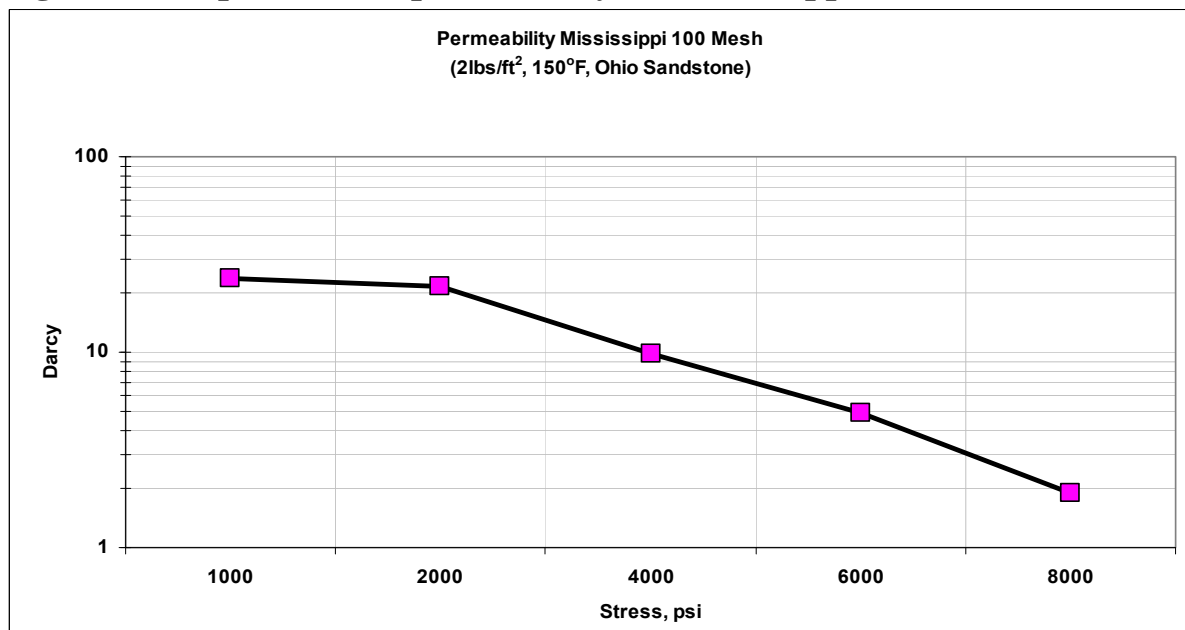
RFA# 400-08-06-05-04

Figure 1. Graphic results conductivity for Mississippi 100 Mesh



Stress (PSI)	1,000	2,000	4,000	6,000	8,000
Conductivity (mDft)	444	371	144	67	25

Figure 2. Graphic results permeability for Mississippi 100 Mesh



Stress (PSI)	1,000	2,000	4,000	6,000	8,000
Permeability (Darcy)	24	23	10	5	2
Width, inches	0.218	0.201	0.173	0.161	0.154



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Table 3- Data table for Mississippi Sand 100 mesh

Sample: BotMid Miss. Sand 100 mesh															
Date: 5.30.08															
Sample Stress,psi	Isco, psi	Date/Time	Conductivity		Permeability		DP Gauge		Temp. 'F	Rate		Rate		Viscosity cps	
			Initial md-ft	Final md-ft	Initial Darcy's	Final Darcy's	psi	psi		initial in H2O	Rate final in H2O				
1000	500	5.30.08-5.31.08	444		24		0.120935		150	4.45	3.350			0.450	
0.218															
2000	975	5.31.08-6.2.08	402	353	23	21	0.160645	0.133209	150	5.35	4.450	3.9	3.690	0.450	
0.209			410	373	23	22	0.130321	0.164616	150	4.43	3.610	5.09	4.560	0.450	
0.201			417	387	23	23	0.102524	0.199272	150	3.55	2.840	6.39	5.520	0.450	
			410	371	23	22	0.131116	0.16570							
4000	1955	6.2.08-6.4.08	154	158	10	11	0.488794	0.375079	150	6.26	13.540	4.9	10.390	0.450	
0.181			184	132	12	9	0.387353	0.561355	150	5.92	10.730	6.14	15.550	0.450	
0.173			164	143	11	10	0.318041	0.209741	150	4.32	8.810	2.49	5.810	0.450	
			167	144	11	10	0.39806	0.38206							
6000	2959	6.4.08-6.6.08	88	65	6	5	0.697091	0.781926	150	5.06	19.310	4.24	21.660	0.450	
0.167			86	60	6	4	0.466051	0.633194	150	3.31	12.910	3.17	17.540	0.450	
0.161			86	74	6	5	0.631028	0.910442	150	4.5	17.480	5.61	25.220	0.450	
			86	67	6	5	0.59806	0.77519							
8000	3925	6.6.08-6.8.08	36	22	3	2	1.195632	1.756265	200	4.97	33.120	4.55	48.650	0.323	
0.158			40	29	3	2	0.731747	1.301405	200	3.37	20.270	4.29	36.050	0.323	
0.154			33	24	2	2	1.11188	1.340393	200	4.19	30.800	3.75	37.130	0.323	
			36	25	3	2	1.01309	1.46602							
10000	4910														

Check Check ✓		Published Data	Miss. Sand 100 mesh Before	Miss. Sand 100 mesh After
Particle Size Dis	Mesh size			
	16		0.00	0.00
	18		0.00	0.00
	20		0.00	0.00
	25		0.00	0.00
	30		0.00	0.00
	35		0.00	0.00
	40		0.00	0.00
	45		0.00	0.00
	50	≤ 0.1	0.00	0.00
	60		0.00	0.46
	70		1.61	1.45
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	100		39.98	30.61
	120		24.71	19.85
	140		10.81	10.52
	200		0.55	0.00
	PAN	< 1.0	0.00	18.77
	Total		100.00	100.00
	In-size (%)	≥ 90	97.84	79.33
Median Particle Diameter (MPD in mms)			0.158	0.141

Photographs

Figure 2 Mississippi 100 Mesh before conductivity test

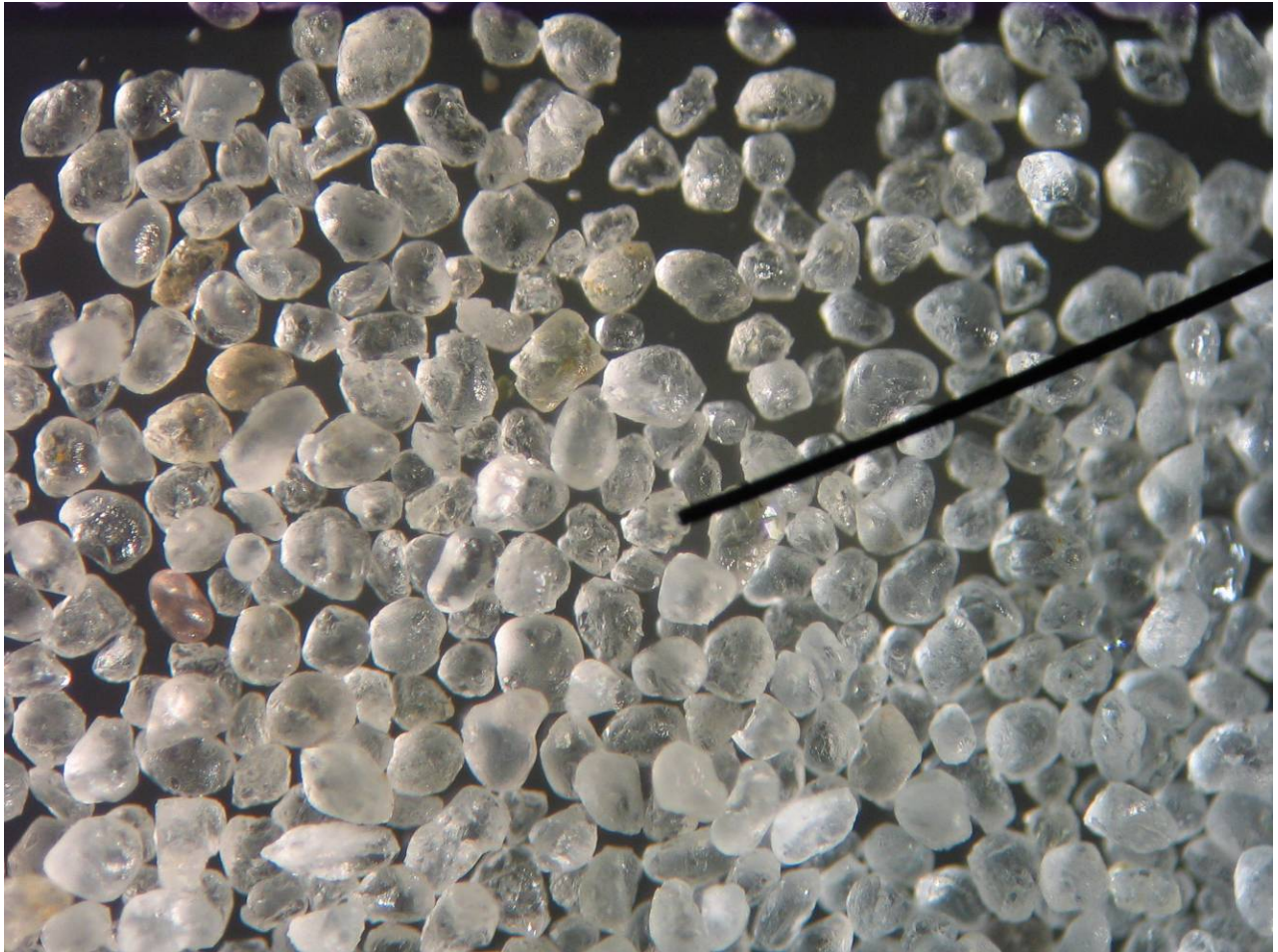
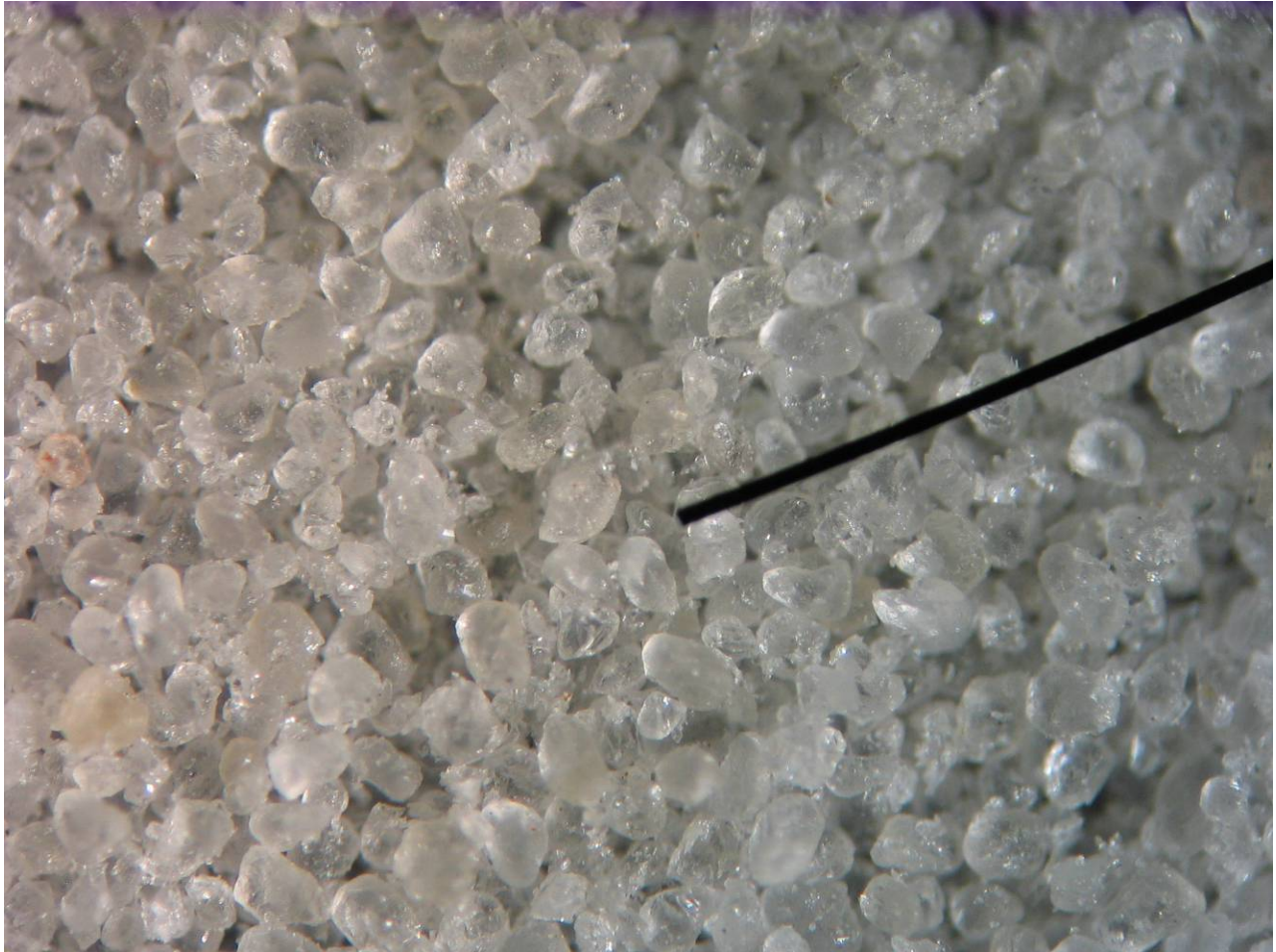


Figure 3 Mississippi 100 Mesh after conductivity test





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