Conductivity and Permeability of the Submitted Samples of
40/70 Roark and 70/140 Roark Frac Sand (Tested in Duplicate)
At 2 lb/ft^2 and at 2,000 - 12,000 psi Closure Stresses
At 150 °F for 50 Hr. between Ohio Sandstone

Prepared for:

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Prepared by:

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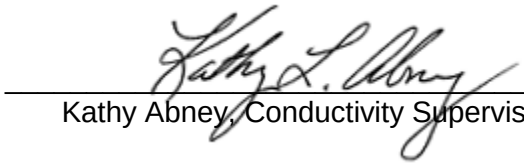

Kathy Abney, Conductivity Supervisor

P.O. Number: PO # 1007

File Number: SL 12217-2

March, 2017

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March 7, 2017

Mr. Dennis Mathis
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Dear Mr. Mathis;

STIM-LAB has completed the evaluations of the requested conductivity of the samples submitted by your firm marked 40/70 Roark and 70/140 Roark frac sand arriving at Stim-Lab on January 23, 2017. The samples were evaluated in duplicate at 2 lb/ft^2 at 150 °F and long-term for 50 hours at 2000, 4000, 6000, 8000, 10,000, and 12,000 psi closure stress between Ohio Sandstone.

The procedures are outlined in the following section of this report. Figures 1 and 2 contain a summary of conductivity and permeability vs. stress. The conductivity data is presented in Tables 1 - 4. The sieve analyses of the samples are provided in Table 5.

Thank you and Turnkey Processing Solutions, LLC for allowing STIM-LAB to perform this test series. If you have any questions, please do not hesitate to call.

Sincerely,

Kathy Abney
Conductivity Supervisor

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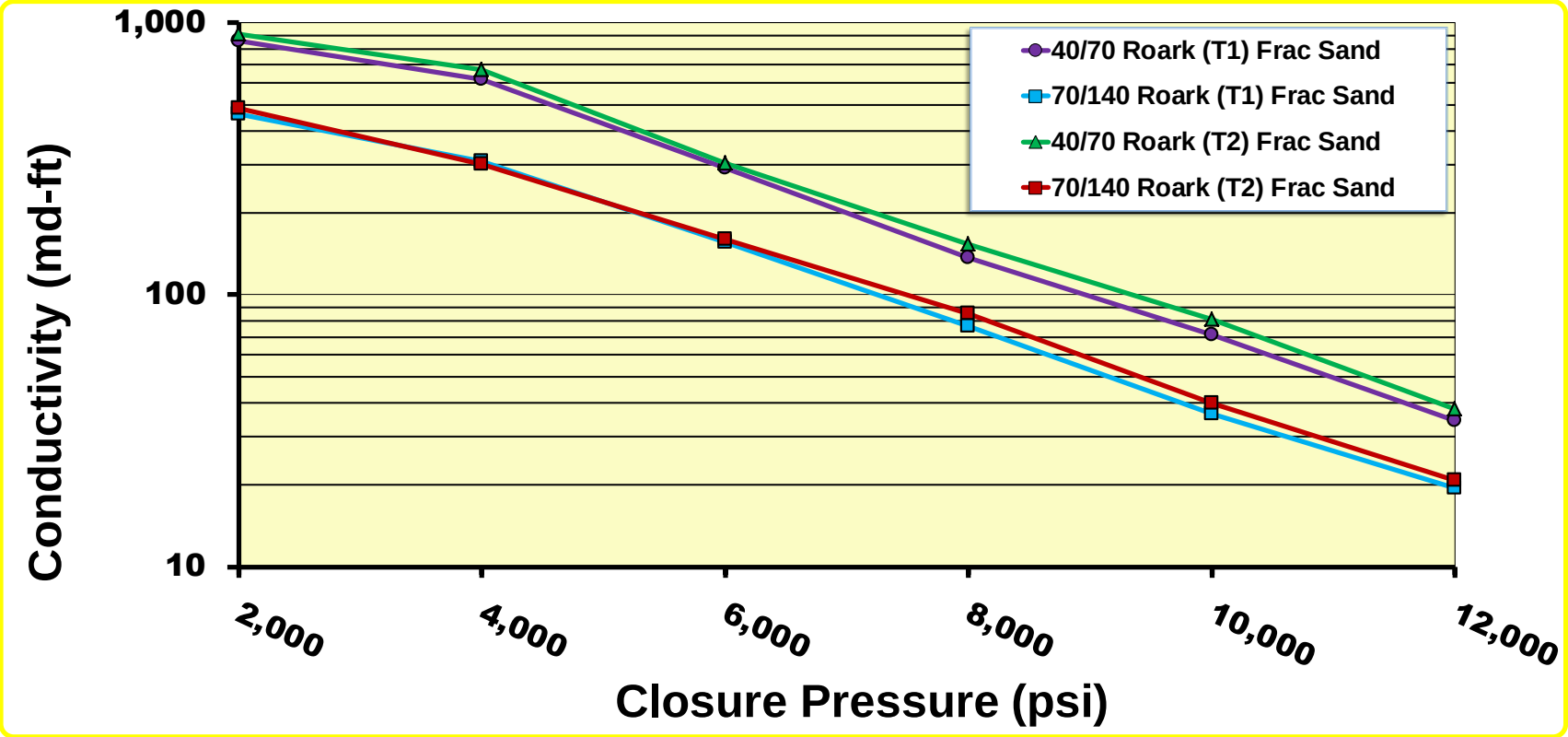
Figure 1

Long-Term Conductivity with 2% KCl between Ohio Sandstone at 150 °F at 2 lb/ft²



Feb. 21 - March 6, 2017

Stress (psi)	2,000	4,000	6,000	8,000	10,000	12,000
40/70 Roark (T1)	860	617	292	137	71	34
70/140 Roark (T1)	463	310	156	76	36	20
40/70 Roark (T2)	911	673	305	153	81	38
70/140 Roark (T2)	485	302	160	85	40	21

***Sample Data Represents the 50 Hour Conductivity Value at the Given Closure Stress**

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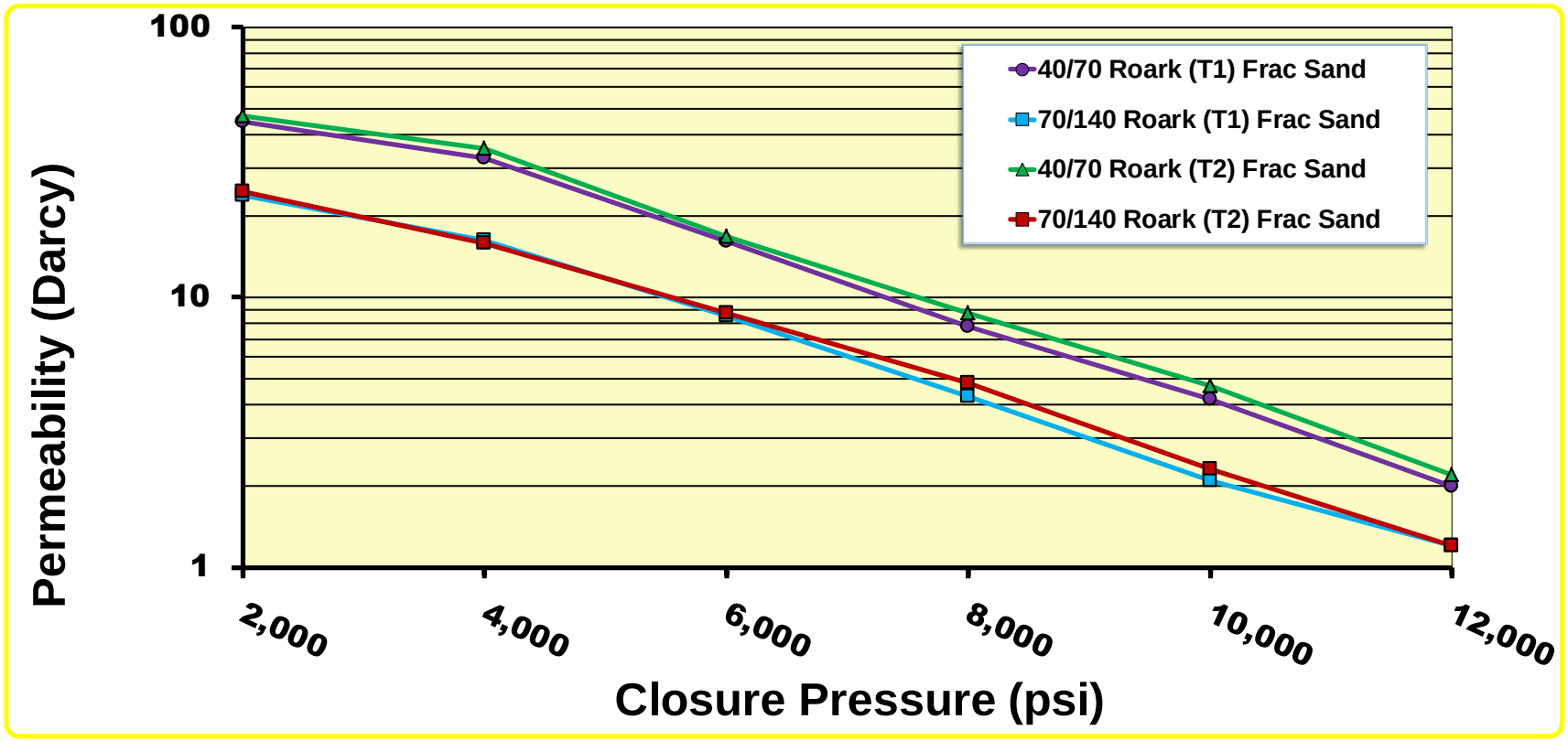
Figure 2

Long-Term Permeability with 2% KCl between Ohio Sandstone at 150 °F at 2 lb/ft²



Feb. 21 - March 6, 2017

Stress (psi)	2,000	4,000	6,000	8,000	10,000	12,000
40/70 Roark (T1)	45	33	16	7.8	4.2	2.0
70/140 Roark (T1)	24	16	8.5	4.3	2.1	1.2
40/70 Roark (T2)	47	36	17	8.7	4.7	2.2
70/140 Roark (T2)	25	16	8.7	4.8	2.3	1.2

***Sample Data Represents the 50 Hour Permeability Value at the Given Closure Stress**

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Table 1

Conductivity and Permeability of

2 lb/ft² 40/70 Roark (T1)

Submitted by Turnkey Processing Solutions, LLC at Stim-Lab on January 23, 2017

In 2% KCl between Ohio Sandstone Core

Hrs at Closure & Temperature	Closure (psi)	Temp (° F)	Conductivity (md-ft)	Width (in)	Permeability (Darcy)
-14	1000	75	926	0.233	48
-2	1000	150	926	0.233	48
0	2000	150	872	0.232	45
10	2000	150	864	0.232	45
20	2000	150	862	0.232	45
30	2000	150	861	0.232	45
40	2000	150	860	0.232	44
50	2000	150	860	0.232	45
0	4000	150	724	0.228	38
10	4000	150	654	0.227	35
20	4000	150	638	0.226	34
30	4000	150	629	0.226	33
40	4000	150	622	0.226	33
50	4000	150	617	0.226	33
0	6000	150	455	0.222	25
10	6000	150	349	0.219	19
20	6000	150	325	0.218	18
30	6000	150	310	0.218	17
40	6000	150	300	0.218	17
50	6000	150	292	0.218	16
0	8000	150	237	0.216	13
10	8000	150	172	0.212	9.7
20	8000	150	157	0.212	8.9
30	8000	150	148	0.211	8.4
40	8000	150	142	0.211	8.1
50	8000	150	137	0.211	7.8
0	10000	150	114	0.210	6.5
10	10000	150	86	0.208	5.0
20	10000	150	80	0.207	4.6
30	10000	150	76	0.206	4.4
40	10000	150	73	0.206	4.3
50	10000	150	71	0.206	4.2
0	12000	150	58	0.204	3.4
10	12000	150	43	0.203	2.5
20	12000	150	39	0.203	2.3
30	12000	150	37	0.202	2.2
40	12000	150	36	0.202	2.1
50	12000	150	34	0.202	2.0

Feb. 21 - March 6, 2017

			Sieve	% Retained
			30	0.0
			35	0.0
			40	0.0
			45	4.2
Median Dia. =	0.262	mm	50	8.8
	0.0103	inch	60	45.3
Mean Dia. =	0.266	mm	70	40.3
	0.0105	inch	80	1.3
			100	0.0
			pan	0.0
			Total	100.0
			% In Size as -40+70	98.6

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Table 2

Conductivity and Permeability of

2 lb/ft² 70/140 Roark (T1)

Submitted by Turnkey Processing Solutions, LLC at Stim-Lab on January 23, 2017

In 2% KCl between Ohio Sandstone Core

Hrs at Closure & Temperature	Closure (psi)	Temp (° F)	Conductivity (md-ft)	Width (in)	Permeability (Darcy)
-14	1000	75	522	0.236	27
-2	1000	150	515	0.235	26
0	2000	150	486	0.234	25
10	2000	150	471	0.234	24
20	2000	150	468	0.234	24
30	2000	150	466	0.234	24
40	2000	150	464	0.234	24
50	2000	150	463	0.234	24
0	4000	150	370	0.232	19
10	4000	150	331	0.230	17
20	4000	150	322	0.229	17
30	4000	150	317	0.229	17
40	4000	150	313	0.229	16
50	4000	150	310	0.229	16
0	6000	150	223	0.225	12
10	6000	150	179	0.222	9.7
20	6000	150	169	0.221	9.2
30	6000	150	163	0.221	8.9
40	6000	150	159	0.220	8.7
50	6000	150	156	0.220	8.5
0	8000	150	124	0.217	6.9
10	8000	150	93	0.215	5.2
20	8000	150	86	0.214	4.8
30	8000	150	82	0.214	4.6
40	8000	150	79	0.213	4.4
50	8000	150	76	0.213	4.3
0	10000	150	61	0.212	3.5
10	10000	150	44	0.210	2.5
20	10000	150	41	0.209	2.3
30	10000	150	39	0.208	2.2
40	10000	150	37	0.208	2.2
50	10000	150	36	0.208	2.1
0	12000	150	33	0.207	1.9
10	12000	150	25	0.204	1.5
20	12000	150	23	0.203	1.3
30	12000	150	21	0.203	1.3
40	12000	150	20	0.202	1.2
50	12000	150	20	0.202	1.2

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			Sieve	% Retained
			50	0.0
			60	0.0
			70	3.6
			80	59.1
Median Dia. =	0.178	mm	100	24.4
	0.0070	inch	120	9.3
Mean Dia. =	0.181	mm	140	2.2
	0.0071	inch	170	1.4
			200	0.0
			pan	0.0
			Total	100.0
			% In Size as -70+140	95.0

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Table 3

Conductivity and Permeability of

2 lb/ft² 40/70 Roark (T2)

Submitted by Turnkey Processing Solutions, LLC at Stim-Lab on January 23, 2017

In 2% KCl between Ohio Sandstone Core

Hrs at Closure & Temperature	Closure (psi)	Temp (° F)	Conductivity (md-ft)	Width (in)	Permeability (Darcy)
-14	1000	75	994	0.233	51
-2	1000	150	992	0.233	51
0	2000	150	934	0.232	48
10	2000	150	919	0.232	48
20	2000	150	915	0.232	47
30	2000	150	913	0.232	47
40	2000	150	912	0.232	47
50	2000	150	911	0.232	47
0	4000	150	774	0.229	41
10	4000	150	708	0.228	37
20	4000	150	693	0.227	37
30	4000	150	684	0.227	36
40	4000	150	678	0.227	36
50	4000	150	673	0.227	36
0	6000	150	492	0.223	27
10	6000	150	378	0.220	21
20	6000	150	346	0.219	19
30	6000	150	328	0.218	18
40	6000	150	315	0.218	17
50	6000	150	305	0.218	17
0	8000	150	272	0.216	15
10	8000	150	195	0.213	11
20	8000	150	177	0.213	10
30	8000	150	166	0.212	9.4
40	8000	150	159	0.212	9.0
50	8000	150	153	0.212	8.7
0	10000	150	145	0.211	8.2
10	10000	150	104	0.209	6.0
20	10000	150	94	0.208	5.4
30	10000	150	88	0.207	5.1
40	10000	150	84	0.207	4.9
50	10000	150	81	0.207	4.7
0	12000	150	68	0.205	4.0
10	12000	150	48	0.203	2.9
20	12000	150	44	0.203	2.6
30	12000	150	41	0.202	2.4
40	12000	150	39	0.202	2.3
50	12000	150	38	0.202	2.2

Feb. 21 - March 6, 2017

			Sieve	% Retained
			30	0.0
			35	0.0
			40	0.0
			45	4.2
Median Dia. =	0.262	mm	50	8.8
	0.0103	inch	60	45.3
Mean Dia. =	0.266	mm	70	40.3
	0.0105	inch	80	1.3
			100	0.0
			pan	0.0
			Total	100.0
			% In Size as -40+70	98.6

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Table 4

Conductivity and Permeability of

2 lb/ft² 70/140 Roark (T2)

Submitted by Turnkey Processing Solutions, LLC at Stim-Lab on January 23, 2017

In 2% KCl between Ohio Sandstone Core

Hrs at Closure & Temperature	Closure (psi)	Temp (° F)	Conductivity (md-ft)	Width (in)	Permeability (Darcy)
-14	1000	75	577	0.237	29
-2	1000	150	550	0.236	28
0	2000	150	507	0.235	26
10	2000	150	493	0.235	25
20	2000	150	489	0.235	25
30	2000	150	487	0.235	25
40	2000	150	486	0.235	25
50	2000	150	485	0.235	25
0	4000	150	364	0.231	19
10	4000	150	324	0.229	17
20	4000	150	315	0.228	17
30	4000	150	309	0.228	16
40	4000	150	305	0.228	16
50	4000	150	302	0.228	16
0	6000	150	223	0.225	12
10	6000	150	182	0.222	9.8
20	6000	150	172	0.221	9.4
30	6000	150	167	0.220	9.1
40	6000	150	163	0.220	8.9
50	6000	150	160	0.220	8.7
0	8000	150	136	0.218	7.5
10	8000	150	103	0.216	5.7
20	8000	150	96	0.215	5.3
30	8000	150	91	0.214	5.1
40	8000	150	88	0.214	4.9
50	8000	150	85	0.214	4.8
0	10000	150	83	0.213	4.7
10	10000	150	55	0.210	3.2
20	10000	150	49	0.209	2.8
30	10000	150	45	0.209	2.6
40	10000	150	42	0.209	2.4
50	10000	150	40	0.209	2.3
0	12000	150	38	0.208	2.2
10	12000	150	27	0.206	1.6
20	12000	150	24	0.205	1.4
30	12000	150	23	0.204	1.3
40	12000	150	22	0.203	1.3
50	12000	150	21	0.203	1.2

Feb. 21 - March 6, 2017

			Sieve	% Retained
			50	0.0
			60	0.0
			70	3.6
			80	59.1
Median Dia. =	0.178	mm	100	24.4
	0.0070	inch	120	9.3
Mean Dia. =	0.181	mm	140	2.2
	0.0071	inch	170	1.4
			200	0.0
			pan	0.0
			Total	100.0
			% In Size as -70+140	95.0

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Table 5

Pre-Test Sieve Analysis of Submitted Samples
Submitted by Turnkey Processing Solutions, LLC at Stim-Lab on January 23, 2017
ISO 13503-2, Section 6, "Sieve Analysis"

Sample I.D.	**Turnkey Processing Solutions, LLC 40/70 Roark - Frac Sand**		**Turnkey Processing Solutions, LLC 70/140 Roark - Frac Sand**	
US Standard Sieve No.	Weight % Retained	Cumulative	Weight % Retained	Cumulative
8	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0
45	4.2	4.2	0.0	0.0
50	8.8	13.0	0.0	0.0
60	45.3	58.3	0.0	0.0
70	40.3	98.6	3.6	3.6
80	1.3	100.0	59.1	62.7
100	0.0	100.0	24.4	87.1
120	0.0	100.0	9.3	96.4
140	0.0	100.0	2.2	98.6
170	0.0	100.0	1.4	100.0
200	0.0	100.0	0.0	100.0
pan	0.0	100.0	0.0	100.0
total	100.0		100.0	
in-size	98.6	% In Size as -40+70	95.0	% In Size as -70+140
Diameter (mm) or d_{50}, 6.5.3	0.262		0.178	
ISO Mean Diameter (mm) 6.5.2	0.266		0.181	

March 2017

Testing Equipment-

1. Hydraulic Load Frame – 4 post design with post diameter of 2.5 in. or 3.5 in. capable of holding within ≤50 psi of the target stress for 50 hr.
2. Test Fluid Drive System – Bladder accumulator capable of maintaining less than 1.0% variations in pressure fluctuations. The system is removed of oxygen through nitrogen purge over copper to 15 ppb.
3. Closure Pressure Control – Teledyne ISCO D-Series, Model 260D, syringe pump equipped with Rosemount 10,000 psi Transducer.
4. ΔP Monitoring – Rosemount 0.9 psi Transducer.
5. Flow Control – Bronkhorst LIQUI-FLOW® mass flow meter/controller (L23-RBD-22-K-70S and C%I-ITU-22-K) down stream flow meter/controller.
6. User interface - National Instruments Data Acquisition Hardware.
7. Computer – Dell Optiplex.
8. Temperature Control – PID Temperature controllers.
9. Silica Saturation – High pressure cylinder with a capacity of 300 mL loaded with 20/40 - 50 mL and 70/140 – 250 mL washed northern white frac sand. The cylinder is held in a thermal jacket. The temperature of the sand columns is held at 30 °F above the test temperature during the collection of data once heated. There is no temperature applied for the initial cold readings. There is a 7 micron filter attached to the back side of the sand column prior to prevent inclusion of suspended silica particles into the proppant pack.
10. Conductivity Cell Stack – The system has a maximum capacity of 4 conductivity cells stacked similar to that shown in Figure A.

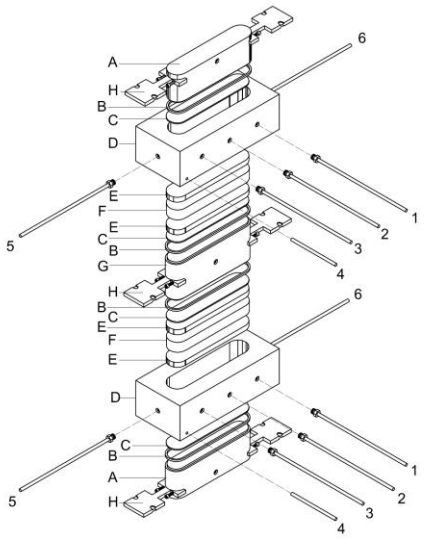

Figure A: Example of Conductivity Cell

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Loading the Sample-

The sample is loaded at 64 g. This is ~2.00 lb/ft^2. Through in-depth studies, it was determined that no one cell is exactly the same width as another and changes with time. We have normalized our loading to 64.00 g to minimize the mis-loading of each cell. This allows for a more uniform consistency between multiple cells. All the cells used in this study were redesigned based on a detailed engineering study to maximize the resistance to expansion from use and still have a total weight that can be handled
Actual Cell Dimensions are 9.5 in. by 4.5 in. by 2.75 in. which is larger than the suggested cell dimensions of 9.0 in. by 4.0 in. by 2.75 in.

The sample is placed into a vibratory feeder, and fed into a pluviation device. Once sample is pluviated into the cell, a leveling device is used to level the proppant throughout the dimensions of the cell.

Once the sample is leveled, the top core is placed onto the proppant and the cells assembled (up to 4 in a stack) in similar fashion as shown in Figure A.

Loading the Test Cells into the Hydraulic Press and Startup Protocol

The cells are loaded into the press and the closure pressure is set to a minimum of 800psi. A carpenter's square is used to ensure the vertical alignment of the cells.

2% KCl is flowed through the cell to saturate the proppant pack and remove any residual air.

The ΔP lines are attached and the plumbing of the manifold is purged through the ΔP lines to remove any air trapped in the entire system.

The internal pressure of the system is brought to 400 psi. The system is checked for leakage. The closure pressure of the system is set to 1400 psi (1000 psi absolute stress). Flow is initiated through the cells and an initial room temperature conductivity reading is taken for each cell in the series.

Initial absolute stress of 1000 psi is maintained for a minimum of 12 hours for resin coated products and 2 hours for uncoated products at the required test temperature. Back pressure is maintained at 400 psi. After the initial stress of 1000 psi and time is achieved, the stress is raised to 2000 psi and maintained for 50 hours. Subsequent test stresses are raised in 2000 psi increments at 100 psi/min. All subsequent test stresses are also maintained for 50 hours at the given stress.

Acquiring data –

Conductivity is measured at 2000, 4000, 6000, 8000, 10,000, and 12,000 psi closure stress at 150 °F.

The test fluid for the conductivity testing was 2% KCl. Flow rates are controlled with a Bronkhorst Liqui-Flow® mass flow meter/controller. The test flow rates were cycled at ~2 mL/min, ~3 mL/min, ~4 mL/min, ~3 mL/min, and ~2 mL/min or to maintain a ΔP of at least a minimum of 0.002 psi. Each rate was maintained for 3 minutes. After the 15 minute cycle, the

cell is switched to the next cell in the test series and the cycle repeated. During the non-monitoring time, the other cells are held at a constant flow of ~2 mL/min. Once data is collected on all cells, the cycle returns to the first cell in the test series and the above protocol continued. This schedule is maintained throughout the 50 hours of data collection at each stress.

Pack widths are measured every 5 hours and recorded as described in the **"Width Measurement"** section.

The transducer zero is checked every 5 hours and if necessary is re-zeroed with a HART 475 Field Communicator.

The raw data is monitored in real time saving one point every 10 seconds. The relevant data collected is as followed: Flow rate (mL/min), Δ*P* (psi), and Temperature (°F). These are used with the Conductivity Equation **("Data Processing to Arrive at Conductivity and Permeability Values"**) to arrive at the calculated conductivity value.

Temperature/Viscosity Correlation –

In order to correct for the temperature effect on viscosity of 2% KCl, the Laliberté equation was utilized.

Mark Laliberté, "Model for Calculating the Viscosity of Aqueous Solutions", *J. Chem. Eng. Data*, **2007**, 52, 321-335.

Data Processing to Arrive at Conductivity and Permeability Values –

1. All of the relevant data collected is processed in Excel. The conductivity calculated as previously described is plotted against elapsed time (min.) for given closure stress.
2. A Logarithmic regression is drawn through all of the collected data and an equation of the regression is generated. Y=mx+b where Conductivity = Slope*LN(time)+intercept
3. The resulting equation is used to calculate the conductivity at given time.
4. Note: The reported zero hour number is established at Time = 30 min.

All Conductivity Data shown in the data tables are processed via the above methods

The permeability is calculated from the conductivity value and the width at the given time using the below referenced equations. The equations used are displayed below

Conductivity (kW_f) = $26.78\mu Q/$ (ΔP)

Q = Flow Rate (mL/min) μ = Viscosity ΔP = Change in pressure

Permeability (k) = Conductivity (md-ft)*.012 / width (in.)

Width Measurement – “To accurately measure the width of the proppant pack, the variations in sandstone thickness, the compressibility of the sandstone and the compression and thermal expansion of the metal shall be taken into account” Reference ISO 13503-5.

1. Pistons of the respective stack are placed between the platens of the press and subjected to a closure pressure of 8,000 psi. The widths are then taken at the 4 corners of the pistons. This is recorded as the zero widths of the pistons.
2. Each piece of the Ohio Sandstone that is used for the test series is measured at 4 corners of the sandstone wafer. These widths must be within 0.003 in of each other or the sandstone core is discarded and a new one selected.
3. Each shim (top and bottom) is measured at each end. The overall width is averaged to determine the shim width.
4. Items 1-3 are added together to determine the width of the test stack per each cell. This is without any proppant in place.
5. During the test, the widths are taken every 5 hours at each of the 4 points on the width slat.
6. Zero width factors are subtracted from the test width to arrive at a pack width, per given closure pressure and time, at each of the 4 corners. This is further averaged to determine the overall uncorrected proppant pack width.
7. In order to correct the proppant pack width, the expansion of metal factor is subtracted and the compression of core factor is added to arrive at the actual proppant pack width per given stress.