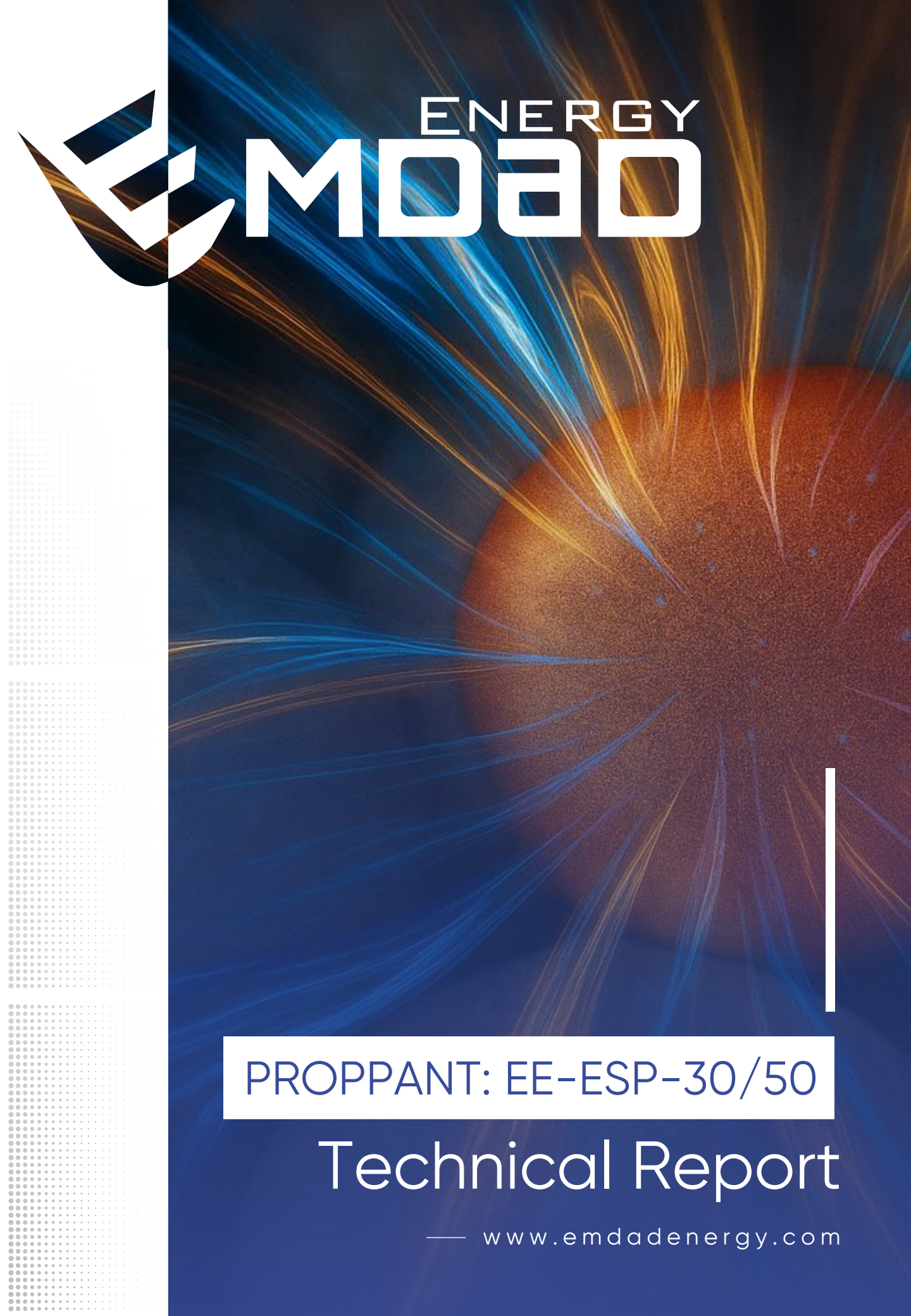

PROPPANT: EE-ESP-30/50

Technical Report

www.emdadenergy.com

Contents

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P.O. Box: 110, P.C: 130, Al Azaiba, Muscat, Sultanate of Oman

SUMMARY

A sample of EE-ESP-30/50 proppant provided for testing by **EMDAD ENERGY LLC.**

Testing was carried out in accordance with the ISO 13503-2 suite of tests covering: crush resistance, bulk density, acid solubility, turbidity, sphericity and roundness and sieve analysis. Apparent and Absolute densities were also determined.

The baseline conductivity and permeability tests of the sample were performed with a loading of 2lb/ft2, at closure stresses of 2, 4, 6, 8, 10 and 12kpsi, at 250°F and each maintained for 50 hours between Ohio sandstone. This was carried out as per ISO 13503-5.

Tabulated overleaf are summaries of results obtained from the ISO 13503-2 suite of tests. The full results of all the tests can be found in the main body of the report.

A photomicrograph of the proppant is given in Appendix A.

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Parameters		ESP 30/50
Crush Test (PSI)	10000	2.2 ± 0.1
	12000	3.0 ± 0.1
Sieve Analysis (90% 30/50)		98.7 ± 0.1
Sieve Analysis (0.1% +20)		0.0 ± 0.0
Sieve Analysis (1% -60)		0.0 ± 0.0
Mean Size(mm)		0.495 ± 0.001
Sphericity		0.9 ± 0.1
Roundness		0.8 ± 0.1
Bulk Density (g/cm^3)		1.67 ± 0.00
Apparent Density (g/cm^3)		3.05 ± 0.00
Absolute Density (g/cm^3)		3.05
Acid Solubility (%)		6.5 ± 0.0
Turbidity (FTU)		21 ± 1

Table i: Summary of ISO 13503-2 Test Suite
Results on Proppant Sample

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Experimental Procedures

1. Apparent Density Procedure

A dry density bottle, with stopper, was weighed (W1). Approximately 30g of proppant was added and the bottle re-weighed (W2). Mineral oil was added to cover the proppant and fill the bottle ¾ full. The bottle was then vacuumed to an absolute pressure of less than 30 mbar for approximately thirty minutes.

More mineral oil was added to fill the bottle. The stopper was then placed in the neck. Excess oil was wiped off, being careful not to suck fluid through the capillary in the stopper. The full bottle was weighed (W3). The proppant and oil were disposed of and the bottle refilled with oil only. The stopper was placed in the neck and the bottle dried and weighed again (W4). This procedure was repeated.

The Apparent Density is then given by,
(W2- W1) / ((W4 - W3) + (W2 - W1)

2. Absolute Density Procedure

The absolute density was calculated using a helium pycnometer.

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3. ISO 13503-2 Methods

The following tests were performed in exact accordance with the ISO 13503-2 procedures. The relevant sections are as follows:

Section	Test/Procedure
5.2	Sample Splitting
6	Sieve Analysis
7	Sphericity and Roundness
8	Acid Solubility (tests run using NH4HF2 as source)
9	Turbidity
10.3	Bulk Density
11	Crush Resistance (2" cell used with pluviator)

Table 1: ISO Procedures

**Crush testing was performed at pressures of 10000 and 12000psi.*

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Baseline Fracture Conductivity & Permeability Procedure

The Fracture Conductivity Cells allow for samples of proppant of various loading to be subjected to closure stress and temperature over extended time. Fluids are flowed through the pack and from differential pressure measurements the flow capacity of the pack can be determined. A schematic of the experimental set-up is given below. The cell is essentially a modified 10 square inch API conductivity cell.

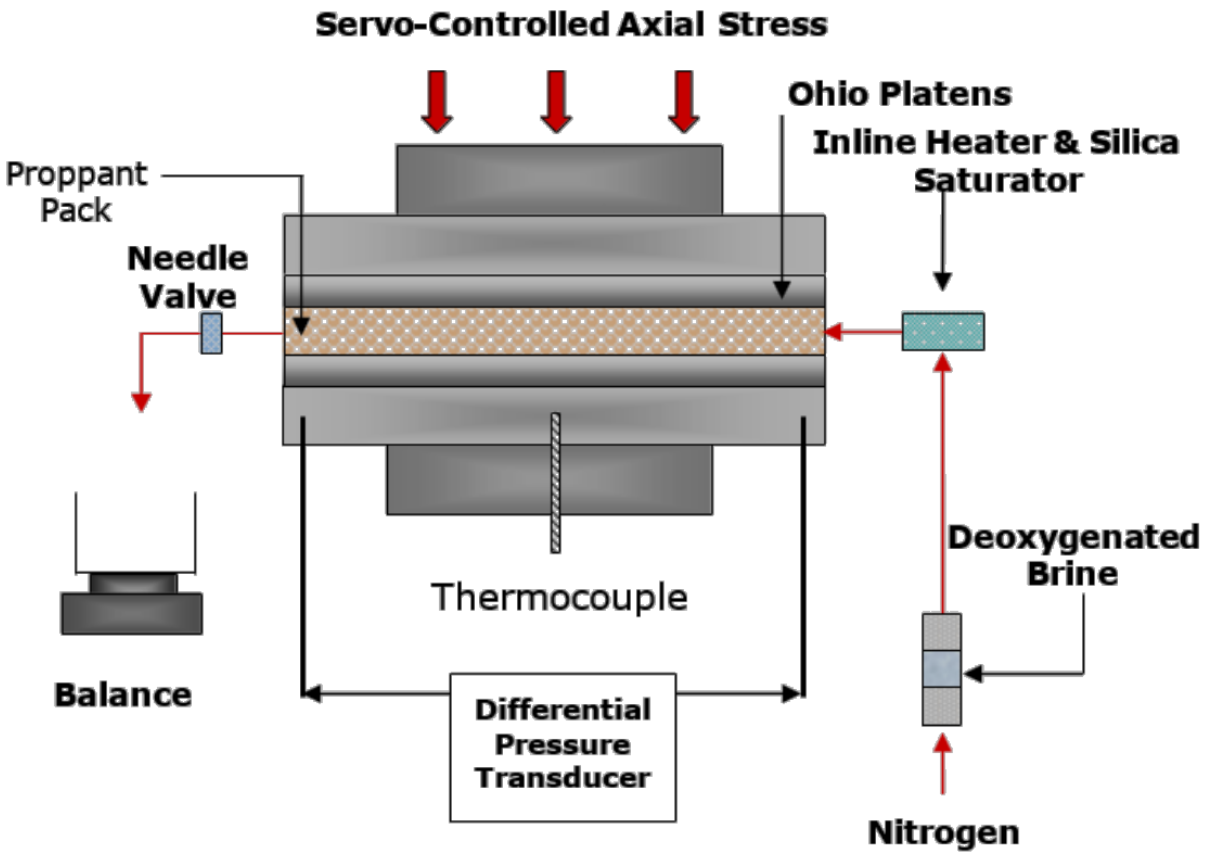

Figure 1: Configuration of Conductivity Cell

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1. Outcrop rocks were selected. For these tests, Ohio sandstone was used. Ohio sandstone has a static elastic modulus of approximately 4 million-psi and a permeability of 0.1mD. Wafers of thickness 9.5mm were machined to 0.05mm precision and one rock was placed in the cell.

2. The selected proppant was sample split and weighed out. Sample splitting ensured that a representative sample was achieved in terms of its particle size distribution.

3. In cell 1, the proppant was placed into the cell and levelled. The top rock was then inserted.

4. Heated steel platens provided the correct temperature simulation for the test. A thermocouple inserted in the middle port of the cell wall recorded the temperature of the pack. A servo-controlled loading ram provided the closure stress.

5. The cells were initially set at 80°F and 1000psi. The cells were then heated to 250°F and held for 15 hours at 1000psi before being ramped to 2000psi over 10 minutes. After 50 hours a set of measurements was made before the stress was ramped to 4000psi (total time: 115 hours).

6. Further measurements were made at 6000, 8000, 10000 and 12000psi at intervals of 50 hours, corresponding to a total time of 315 hours.

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7. Conductivity measurements were made using the following procedure:

I. A 70mbar full range differential pressure transducer was activated by closing the bypass valve and opening the low pressure line valve (the second valve is there to prevent fluid flow bypassing the cell itself while the d.p. bypass is open).

II. Flow was generated and maintained by a piston pump located downstream of the cell. The pump can control flow rates down to 10-5cm3/min with a resolution of 2mm3. Fluid was flowed at rates as specified by the ISO procedure. When the differential pressure appeared to be stable, data was logged every second for a 3 minute interval. The output from the differential pressure transducer was fed to a data logger 5 digit resolution multi-meter.

III. The mean value of the differential pressure was retrieved from the multi-meter together with the peak high and low values. If the difference between the high and low values was greater than the 5% of the mean, the data was disregarded.

IV. Temperature was recorded from the inline thermocouple at the start and end of the flow test period. If the temperature variation was greater than 0.5 degrees K the test was disregarded. Viscosity of the fluid was obtained from using the measured temperature and viscosity tables. For brine at 100psi, no pressure correction was made. The density of brine at elevated temperature was obtained from these tables.

V. At least five permeability determinations were made at each stage. The standard deviation of the determined permeabilities should be less than 1% of the mean value for the test sequence to be considered acceptable.

VI. At the end of the permeability testing, the widths of each of the four corners of the cell were determined using vernier callipers, to 0.01mm resolution.

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RESULTS

Sieve Analysis Results

The result of the sieve analysis is tabulated below:

ASTM Mesh	ESP 30/50			
	% Proppant (A) by weight	% Proppant (B) by weight	% Average by weight	Standard Deviation
+20	0.00	0.00	**0.0**	0.0
-20 +30	1.29	1.40	**1.3**	0.1
-30 +35	38.67	39.50	**39.1**	0.6
-35 +40	52.01	51.47	**51.7**	0.4
-40 +45	7.65	7.40	**7.5**	0.2
-45 +50	0.39	0.23	**0.3**	0.1
-50 +70	0.00	0.00	**0.0**	0.0
-70	0.00	0.00	**0.0**	0.0
Total	100.0	100.0	100.0	
%30/50	98.7	98.6	**98.7**	0.1
Mean Size(mm)	0.494	0.495	**0.495**	0.001

Table 2: Proppant Sieve Analysis Results

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Bulk, Apparent & Absolute Densities Results

The results of the Bulk, Apparent & Absolute Densities are tabulated as follows:

Sample	Bulk Density (g/cm3)	Standard Deviation (g/cm3)	Apparent Density (g/cm3)	Standard Deviation (g/cm3)	Absolute Density (g/cm3)
ESP 30/50	1.67	0.00	3.05	0.00	3.05

Table 3: Bulk, Apparent & Apparent Density Results

Acid Solubility Results

The results of the acid solubility are tabulated below:

Sample	Test No.	% Loss, By Mass	Average % Loss, By Mass	Standard Deviation % Loss, by Mass
ESP 30/50	1	6.473	6.5	0.0
	2	6.469		

Table 4: Acid Solubility Results

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Sphericity & Roundness Results

The results of the sphericity & roundness are tabulated below:

ESP 30/50		
Sample Reference	**Sphericity**	**Roundness**
1	0.9	0.9
2	0.9	0.7
3	0.9	0.9
4	0.9	0.9
5	0.9	0.9
6	0.9	0.9
7	0.9	0.9
8	0.9	0.7
9	0.9	0.9
10	0.9	0.7
11	0.9	0.7
12	0.9	0.9
13	0.9	0.7
14	0.9	0.9
15	0.9	0.7
16	0.9	0.9
17	0.9	0.9
18	0.9	0.9
19	0.9	0.9
20	0.9	0.9
Mean	**0.9**	**0.8**
Standard Deviation	**0.0**	**0.1**

Table 5: Sphericity & Roundness

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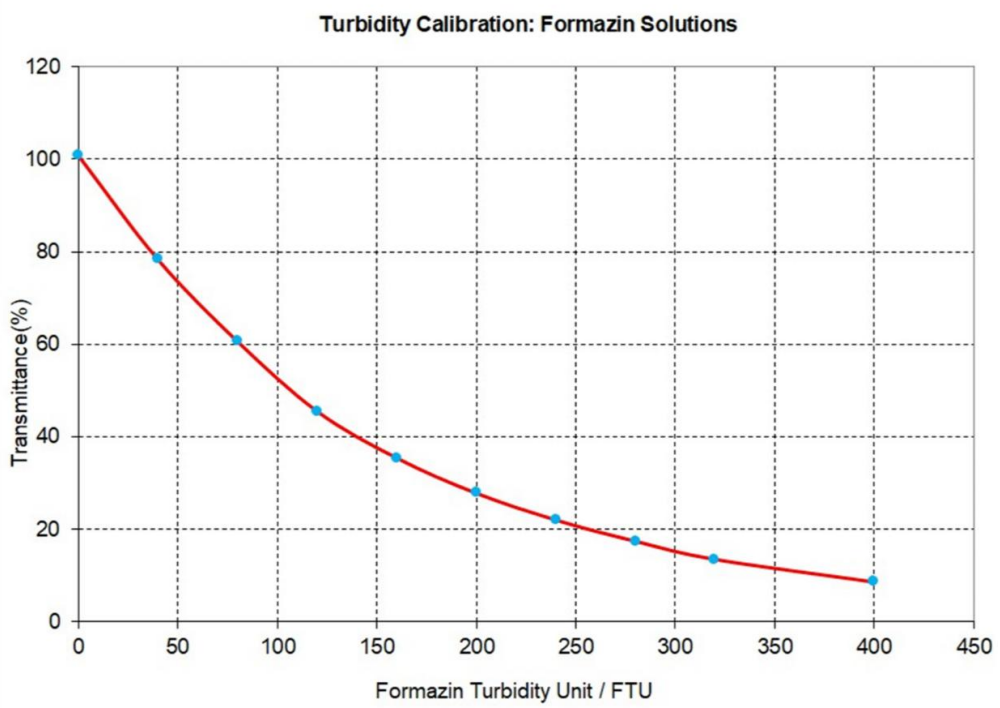
Turbidity Results

The following table and graph show the spectrophotometer calibration

Solution/FTU	Transmittance/%
0	100.8
40	78.3
80	60.6
120	45.5
160	35.4
200	27.8
240	22.0
280	17.4
320	13.5
400	8.6

Table 6: Turbidity Calibration



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Sample	Measured Sample Transmitttance (%)	Turbidity (FTU)	Mean Turbidity (FTU)	Standard Deviation (FTU)
ESP 30/50	89.2	20	21	1
	88.4	21.5		

Table 7: Turbidity Results

Crush Resistance Results

The results of the crush resistance tests are tabulated below.

Stress (psi)	ESP 30/50		
	% Fines, By Mass	Average % Fines, by Mass	Standard Deviation (% Fines, by Mass)
10000	2.82	2.2	0.1
	2.66		
12000	3.96	3.0	0.1
	3.58		

Table 8: Crush Resistance Results

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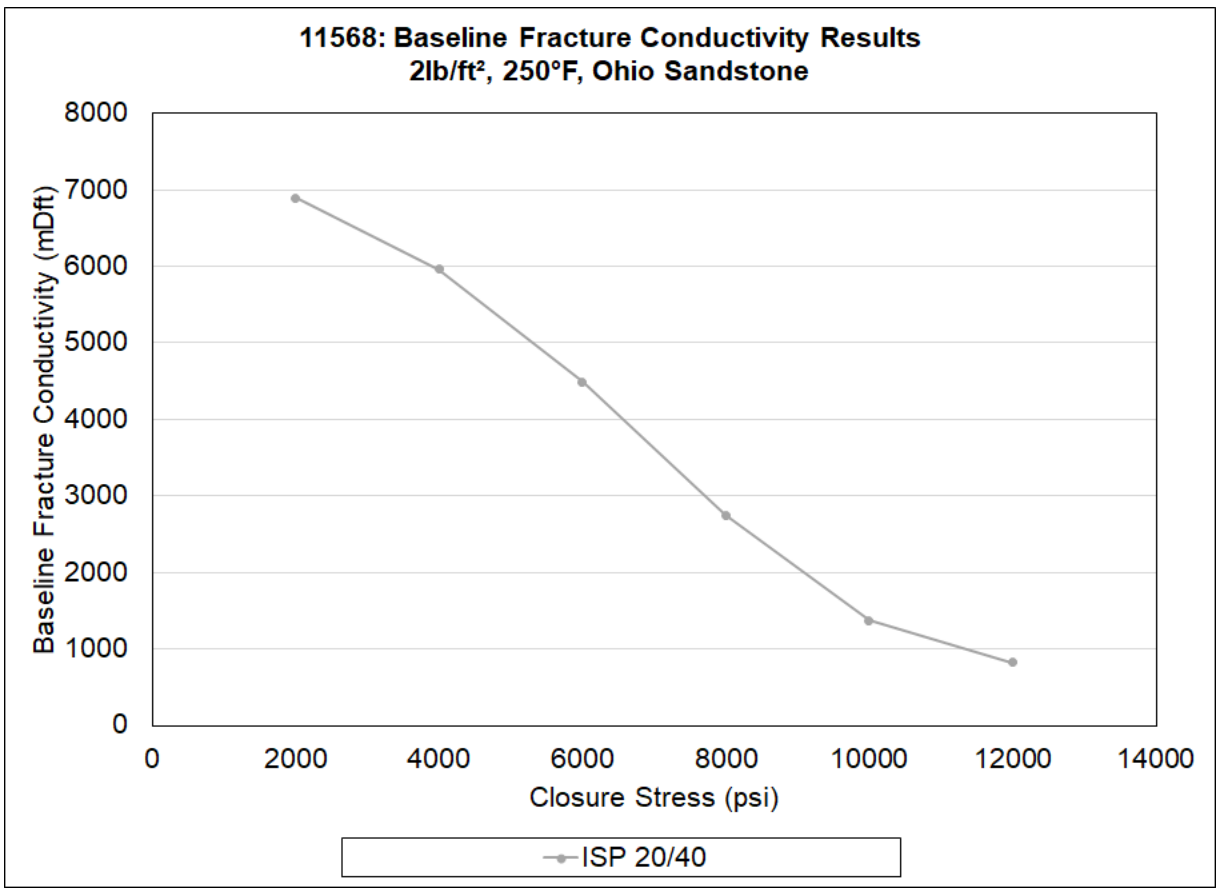
Baseline Fracture Conductivity and Permeability Results

Closure Stress (psi)	ESP 30/50		
	Baseline Fracture Conductivity (mDft)	Baseline Permeability (Darcy)	Pack Width (mm)
2000	3780	223	5.16
4000	3160	193	5.00
6000	2581	162	4.87
8000	2054	132	4.73
10000	1461	96.8	4.60
12000	905	62.1	4.44

Table 9: Baseline Fracture Conductivity, Permeability and Width Results, 2lb/ft², 250°F, Ohio Sandstone



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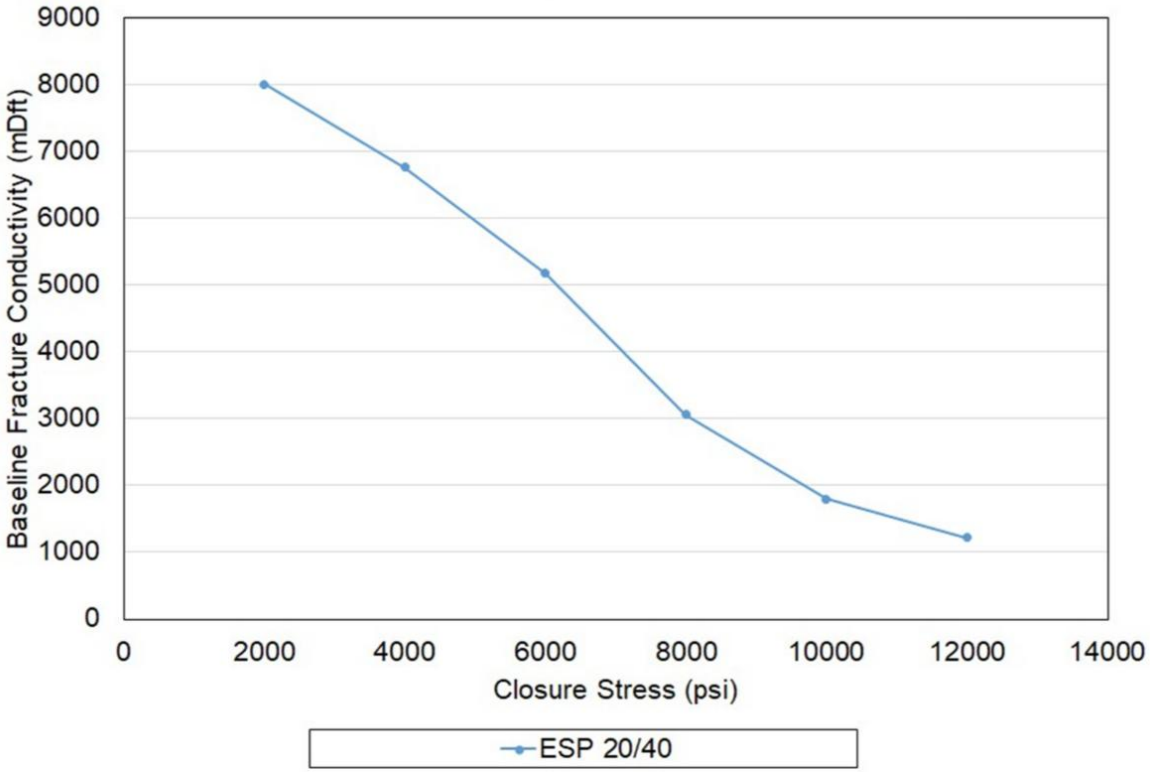
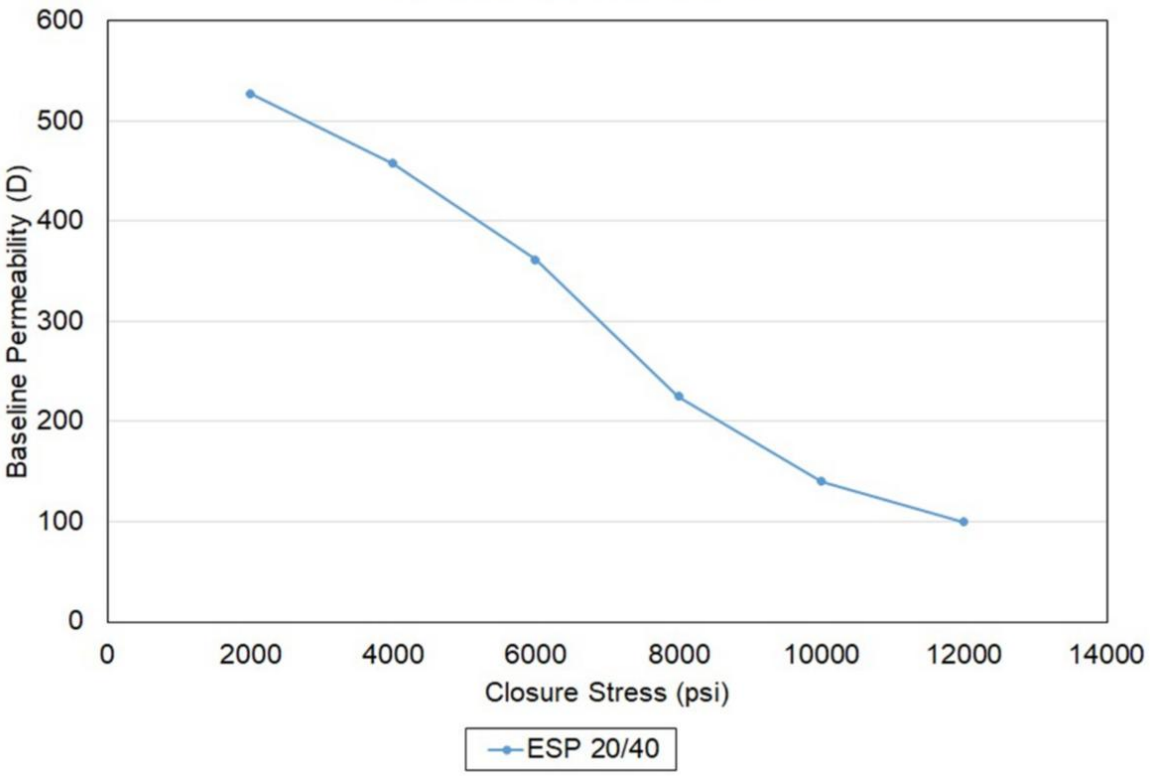
11568: Baseline Fracture Conductivity Results
2lb/ft², 250°F, Ohio Sandstone



11568: Baseline Permeability Results
2lb/ft², 250°F, Ohio Sandstone



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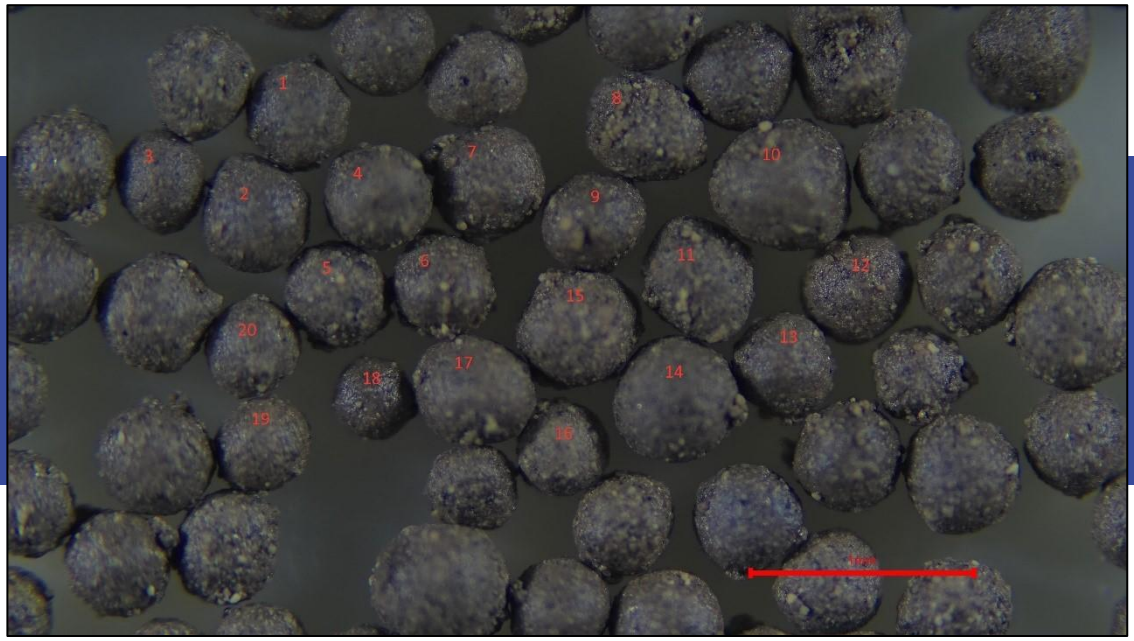
APPENDIX A

Photomicrographs of test sample



Proppant EE-ESP-30/50

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