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API 13C (ISO 13501) Sieve and Conductance Testing
Global Wire Cloth

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INTRODUCTION

At the request of Tom Remy of Global Wire Cloth, the Intertek Westport Technology Center Drilling Fluids Laboratory conducted 3 shale shaker screen sieve and conductance tests.

CONCLUSIONS

API 13C (ISO 13501) shale shaker screen sieve and conductance testing gave the following results:

Global Screen	ASTM API Screen Designation	Brandt Screen Conductance, Kd/mm
165	140	0.80
200	170	0.61
GS250	170	1.09

Test Procedure

Shaker Screen API Sieve Test Procedure

A. Equipment Used

1. W. S. Tyler Ro-Tap, Model RX-29, Serial # 19350, Manufactured by W. S. Tyler Corporation, 8570 Tyler Blvd, Mentor, Ohio, 44060. This Ro-Tap had a rotational speed of 270 to 300 rpm and a stroke speed of 156 per minute.

2. U. S. A. Standard Testing Sieves, A.S.T.M.E.–11 Specification

Sieve Number	Inch Opening	Median Opening, inches
20	0.0332	-
30	0.0233	0.02074
40	0.0165	0.01467
50	0.0117	0.01037
60	0.0098	0.00872
70	0.0083	0.00733
80	0.0069	0.00617
100	0.0058	0.00519
120	0.0049	0.00436
140	0.0041	0.00367
170	0.0035	0.00308
200	0.0029	0.00259
230	0.0025	0.00218
270	0.0021	0.00183
325	0.0017	0.00154
400	0.0015	-
500	0.0001	-

3. AGA (Abrasive Grain Association) Bonded Standard Sands (aluminum oxide), from Washington Mills Electro Minerals Company, P.O. Box 423, Niagara Falls, NY 14302-0423. These sands were prepared in accordance with ANSI B74.12-1992 (Specifications for the Size of Abrasive Grain – Grinding Wheel, Polishing and Industrial Uses).
4. Mettler PE-4000 electronic balance. Two decimal place accuracy.

B. Sieve Screens

Several sieve screens were used in this project. All sieves were two inches deep and eight inches in diameter. Prior to use, each screen was closely inspected to determine the condition of the mesh screen. Screens that were loose or rippled were not used, as this indicates a tear in the screen material. The screens were thoroughly cleaned prior to use by washing with a soft bristle brush and soapy water. After rinsing, the screens were allowed to drain, then placed in an air-circulation oven set at 175°F for one hour. After cooling, the screens were then blown dry with a high-pressure nitrogen line.

1. Before each test, the series of sieves to be used were cleaned and dried, as described above. After drying, the sieves were air-blown to ensure cleanliness.
2. Each screen was weighed on a Mettler PE 4000 electronic balance, to two decimal places.
3. After sieve testing, each screen was re-weighed to determine weight increase. After weighing, the aluminum oxide in each sieve was removed, and the screen was cleaned by using high-pressure air.
4. After each test series, the screens were cleaned with soap and water, then dried.

C. Aluminum Oxide Pre-sieving

All screen tests were conducted with aluminum oxide grit. Aluminum oxide was obtained from Washington Mills Electro Minerals Company, P.O. Box 423, Niagara Falls, NY 14302-0423. When purchased, the aluminum oxide grit is certified as being at least 50% of a certain mesh size.

The test procedure for screen determination is listed below. In order to conduct these tests efficiently, it was necessary to pre-sieve the aluminum oxide into very narrowly defined screen sieve fractions. This was accomplished by sieving with the ASTM screens. For example, to obtain aluminum oxide with a –70 to + 80 mesh size, the material was sieved through a 60, 70, 80, 100, and 120 mesh screen. Fifty grams were sieved for 10 minutes through the screens. (Attempts to sieve more than 50 grams resulted in some of the screens being blinded, retaining some material that would have passed through the screen at lower concentrations). After ten minutes, the screens were cleaned, with the plus fractions of each screen placed in plastic weigh-boats. This process was repeated until the 80 mesh grit was totally sieved. Each sample was sieved in this manner, using the ASTM mesh screens for the testing program.

This process resulted in very narrow fractions of test material. These fractions were placed in glass jars, and identified as to size range. Each size of aluminum oxide grit was then washed (as described in RP 13C), rinsed through the appropriate ASTM screen, dried in a convection oven, then sieved one additional time prior to being used in a test. When this material was used in a test, the material was placed in a second set of marked weigh-boats, then re-sieved (as described above) prior to being used in later tests.

D. Absolute Cut-Point Testing Procedure

1. Calibrate the RoTap as specified by ANSI B74.12-1992, section 2.2.
2. Select the test material sample that corresponds to the estimated screen cut-point.
3. Set up the test sieves (S1 through S6 below) for the RoTap as follows:

    a) S1 – 2 sieve sizes coarser than equivalent screen size
    b) S2 – 1 sieve size coarser than equivalent screen size
    c) S3 – Screen to be tested
    d) S4 – Screen which corresponds to equivalent test screen sample (equivalent screen size)
    e) S5 – 1 sieve size finer than equivalent screen size
    f) S6 – 2 sieve sizes finer than equivalent screen size
    g) Pan – Pan at bottom of sieve stack

4. Make sure that each screen (test screen and sieve stack screens) are clean, dry, and in good condition.
5. Weigh each screen (to two decimal places) on the Mettler Balance.
6. Set screens aside.
7. Weigh out 20.00 grams of pre-sieved material (in a large weigh-boat), in the following manner:

    a) S2 – 5.00 grams of grit, corresponding to S2 screen mesh size
    b) S4 – 5.00 grams of grit, corresponding to equivalent test screen
    c) S5 – 5.00 grams of grit, corresponding to test screen 1 size finer than equivalent test screen
    d) S6 – 5.00 grams of grit, corresponding to test screen 2 sizes finer than equivalent test screen

8. After weighing out the test material, place the material in a 20 mL glass vial. Label the vial as to the equivalent test screen size (S4).
9. Weigh the glass vial containing the test material. Empty contents of vial onto the test screen assembly. Place top on the screens.
10. Reweigh the glass vial to determine the amount of test material added to the screen assembly.
11. Place screen assembly on RoTap. Run for 10 minutes. Remove screen assembly.
12. Carefully remove each screen from the test assembly and reweigh on balance.
13. Determine the weight of test material retained on each screen.
14. Clean each screen, removing the test material (set aside for additional testing) and cleaning the screens with high-pressure air.
15. Repeat this test in triplicate, using a new sample of test material for each fraction (7a through 7d above).
16. After the test is completed, determine the average amount of weight retained on test screen (S3). If the average amount is less than 10 wt% (0.5 grams), repeat the test, using a one size coarser screen designation for the test screen. If the average amount of aluminum oxide retained on the test screen is greater than 90 wt% (4.5 grams), repeat the test, using a one size finer screen designation for the test screen.

E. Calculations

1. Determine amount of test material on each screen. Subtract the tare weight of the screen from the weight of the screen with the test material retained.
2. Calculate the amount of test material retained on both the test screen and the equivalent test screen. Determine percent retained by dividing the amount of test material on the test screen (S3 weight) by the sum of the test material on the test screen and equivalent screen (S3 weight + S4 weight).
3. Determine the average percent retained from three separate tests with the screens.
4. Calculate the API screen designation value of each test screen with an Excel spreadsheet program.
5. Determine the micron size of the test screen value.
6. Determine the API screen designation value from the micron size of the test screen.

F. API Screen Designations

The following table shows the micron size ranges of the various ASTM screens:

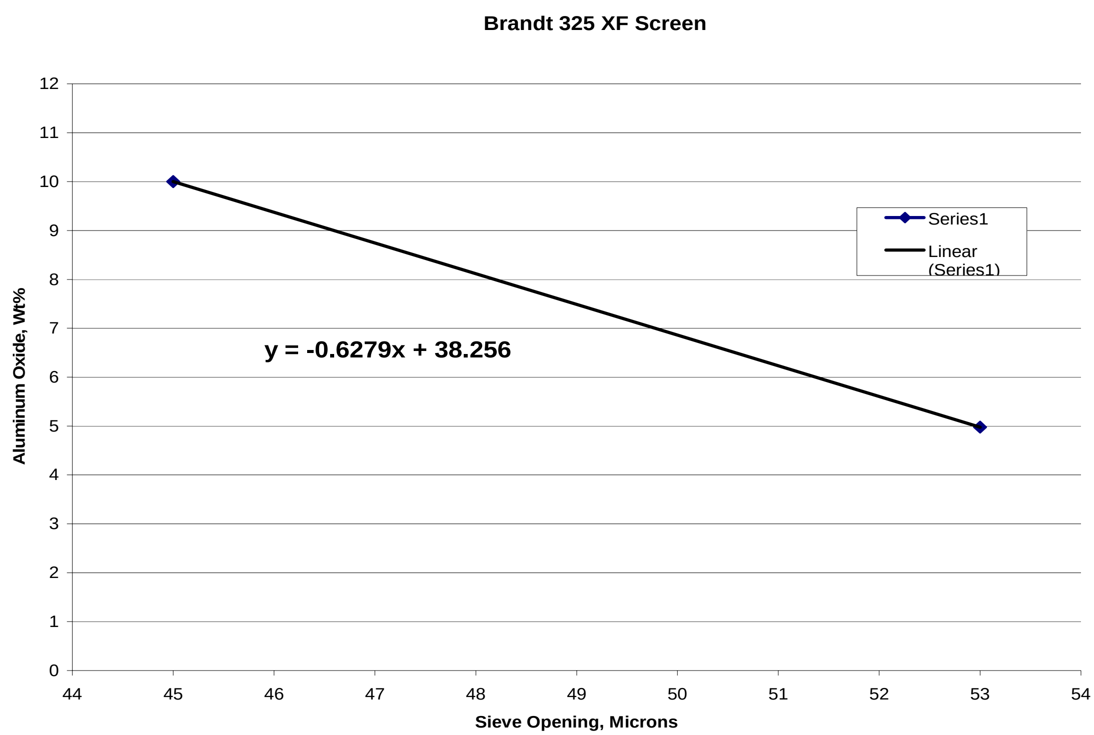
API Screen	Max., µ	Min., µ	API Screen	Max., µ	Min., µ
6	3675	3075	60	275	231
7	3075	2580	70	231	196
8	2580	2180	80	196	165
10	2180	1850	100	165	137.5
12	1850	1550	120	137.5	116.5
14	1550	1290	140	116.5	98
16	1290	1090	170	98	82.5
18	1090	925	200	82.5	69
20	925	780	230	69	58
25	780	655	270	58	49
30	655	550	325	49	41
35	550	462.5	400	41	35
40	462.5	390	450	35	28.5
45	390	327.5	500	28.5	22.5
50	327.5	275	635	22.5	18.5

G. Example Calculation

Using a 270 mesh screen as S2 and a 325 mesh screen as S4, a previous test (Brandt 325 XF) had the following aluminum oxide sieve test result averages:

270 mesh (53 microns)	4.97 grams
325 XF	6.31 grams
325 mesh (45 microns)	10.00 grams

Graphing out the 270 mesh and 325 mesh data points resulted in the following graph:



The slope of the line is equal to:

Y = -0.6279X + 38.526

Solving for x when y equals 6.31 results in:

X = (6.313 – 38.526) / (-0.6279)

X = 51.3 microns

The value of the 325 XF screen is 51.3 microns. This value falls in the range of 270 mesh, which is greater than 49 microns and less than 58 microns. This screen would be designated at a 270 API screen.

General Conductance Testing Procedure

1. Each screen to be tested was mounted in the API Conductivity Testing Device. After mounting, the screen was leveled with a bubble balance. The screen was mounted in 6 inch diameter Schedule 80 PVC pipe. Motor oil (5W-30) was flowed through the screen.
2. Head height of the motor oil was kept constant by diverting oil overflow from the top lip of the pipe into separate containers.
3. Oil flow measurement was obtained by weighing the oil flowing through the screen per unit of time. The viscosity, density, and temperature of the oil was also measured.
4. By measuring oil flow per unit of time, flow rates, permeability, conductance, and flow velocity could be calculated.
5. A second series of tests, using a 1 inch collar on top of the mounted screen, was also conducted. This collar increased the head height of the oil to two inches.
6. A third series of tests, using a 2-inch collar on top of the mounted screen, was also conducted. This collar increased the head height of the oil to three inches.
7. Using the test data collected, the permeability, conductance, and flow rate of each screen was calculated.

Test Screen Set-up

Test screens are mounted with epoxy between two pieces of Schedule 80 PVC pipe. Each piece is 6.5 inches OD, 5.75 inches ID, and one inch tall. Care is taken to make sure that the upper and lower parts of the PVC pipe and screen are “water-tight” so that test fluid does not escape from the sides of the ring. After mounting, the screen thickness is measured with a micrometer. Effective screen diameter is also measured.

Screens are placed in the PVC pipe in such a way as to minimize the closed off area from the screen mounting plate. When successfully mounted, the screen will appear to have mirror images of itself both perpendicularly and horizontally.

Conductance Testing Procedure

1. Place test screen in conductance test screen holder. Make sure that the lower PVC ring top is flush with the bottom of the test screen holder.
2. Measure the top of the screen PVC ring with a bubble balance. Adjust the ring as necessary to be level from front to back and from side to side.
3. Tare balance to 0.00 kg.
4. Open Labview data collection program. Enter oil density data, screen name, head height, and measurement time interval. Begin collection of data.
5. With bottom flow valve closed, open gate valve and spigot valve to bleed air out of the flow assembly.
6. Open bottom flow valve, adjusting flow of oil to fill test screen reservoir. Adjust spigot valve so that oil flows over shoulder of screen to overflow collectors. Oil flow is correct when a film of oil 0.125 inches thick is flowing over ring shoulder.
7. Continue to monitor oil flow during test, making sure that oil continually flows over screen ring.
8. Adjust oil level in reservoir during test.
9. Continue running test until flow rate is very steady and oil collection reservoir is nearly full.
10. At the completion of the test, transfer oil back into top reservoir.
11. Repeat test, adding one-inch collar to screen ring (for 2 inch head).
12. Repeat test, adding two-inch collar to screen ring (for 3 inch head).
13. Download data, entering it into conductivity calculation spreadsheet.

Conductivity Calculation Spreadsheet

1. The flow rate data for each test is graphed out to determine when the oil flow rate becomes steady (the curve flattens out). The oil temperature during this portion of the test is averaged.
2. Test data on the oil (density and viscosity vs. temperature), along with the average oil temperature during the test, is used to determine the density of the oil and its viscosity.
3. The height of the oil column during the test is included in the spreadsheet data. During a standard test, the height of the oil flowing over the screen ring is 0.125 inches. This height is added to the head height.
4. Oil density is converted from lb/gal to specific gravity.
5. The average oil viscosity is calculated, based on previously measured oil viscosity data. Based on the average oil temperature, oil viscosity is =0.1111*(Avg. temp)^2 - 17.5698*(Avg. temp) + 798.041, based on the slope of the oil temperature vs. viscosity graph.
6. Pressure drop, in dynes is calculated by the equation: oil density (s.g.) * 980 * oil head height (inches)*2.54.
7. Pressure drop is converted to psi by multiplying dyne pressure drop by *1.4508*10^-5.
8. Mass flow rate, in kg/min, is calculated from the spreadsheet data. The calculation is from the elapsed time and cumulative oil weight during the flattened part of the flow rate curve.

    INDEX(LINEST(Elapsed time,Oil weight),1)

9. Volume flow rate (cc/min) is calculated by the equation: (mass flow rate * 1000) / oil s.g.

    Screen permeability, in Darcys, is calculated with the following equation:

    Screen permeability, Darcys = (245 * (T/A) * (F/P) * V) / 1000 where:

    T = screen thickness, cm
    A = screen area, cm^2
    F = volume flow rate, cc/min
    P = pressure drop, psi
    V = oil viscosity, cP

10. Volume flow rate, in cubic inches per second, is calculated by multiplying cc/min by 0.001017062.
11. Flow rate through the screen, in inches per second, is calculated by dividing volume flow rate by screen surface area.
12. Permeability, in Darcys, is converted to kilodarcies (Kd) by dividing by 1000.
13. Conductance, in Kd/mm, is calculated by dividing measured permeability by screen thickness, in mm.

TEST RESULTS

Table #1 –Screen Sieve Average Test Results

Global Sieve # 200

Sieve #	Sieve, µ	Test 1, g.	Test 2, g.	Test 3, g.	Test Average, g.	Avg. Test Cum., g.	Avg. % Retained	Cum. % Retained
140	106	0.34	0.35	0.06	0.25	0.25	0.01	0.01
170	90	5.04	5.09	5.16	5.10	5.35	0.26	0.27
200	0	2.47	2.45	2.35	2.42	7.77	0.12	0.39
200	75	3.16	3.13	3.3	3.20	10.97	0.16	0.55
230	63	4.09	4.15	4.22	4.15	15.12	0.21	0.76
270	53	4.13	4.2	4.06	4.13	19.25	0.21	0.97
pan	pan	0.57	0.56	0.69	0.61	19.86	0.03	1.00
					19.86			

Sieve #	Sieve, µ	Al2O3, avg.		
170	90	5.346667	Line equati	y = -0.3747x + 39.067
200	83.52549	7.77	200	= 170 mesh API
200	75	10.96667	**170 mesh**	**> 82.5 µ < 98 µ**

100	165	137.5			
Sieve, µ	Cum., g.		Test Screen Data	7.77	API Sceen
106	0.25				
90	5.346667		90	5.3466667	
0	7.77		75	10.966667	
75	10.96667				
63	15.12		y = -0.3747x + 39.067		
53	19.25				
pan	19.85667		**83.53** µ		

y = -0.3747x + 39.067

Global Sieve # 165

Sieve #	Sieve, µ	Test 1, g.	Test 2, g.	Test 3, g.	Test Average, g.	Avg. Test Cum., g.	Avg. % Retained	Cum. % Retained
120	125	0.12	0.14	0.19	0.15	0.15	0.01	0.01
140	106	5.02	4.91	4.91	4.95	5.10	0.25	0.25
165	0	0.93	0.91	0.89	0.91	6.01	0.05	0.30
170	90	3.95	4.07	4.00	4.01	10.01	0.20	0.50
200	75	4.95	4.97	5.01	4.98	14.99	0.25	0.75
230	63	4.13	4.11	4.16	4.13	19.12	0.21	0.96
pan	pan	0.91	0.9	0.82	0.88	20.00	0.04	1.00
					20.00			

Sieve #	Sieve, µ	Al2O3, avg.		
140	106	5.096667	Line equati	y = -0.3073x + 37.67
165	103.0372	6.006667	**165**	**= 140 mesh API**
170	90	10.01333	**140 mesh**	**> 98 µ < 116.5 µ**

100	165	137.5			
Sieve, µ	Cum., g.		Test Screen Data	6.006667	API Sceen
125	0.15				
106	5.096667		106	5.0966667	
0	6.006667		90	10.013333	
90	10.01333				
75	14.99		y = -0.3073x + 37.67		
63	19.12333				
pan	20		**103.037** µ		

y = -0.3073x + 37.67

Global Sieve # GS-250

Sieve #	Sieve, µ	Test 1, g.	Test 2, g.	Test 3, g.	Test Average, g.	Avg. Test Cum., g.	Avg. % Retained	Cum. % Retained
140	106	0.12	0.39	0.24	0.25	0.25	0.01	0.01
170	90	5.23	4.97	5.11	5.10	5.35	0.26	0.27
GS-250	0	0.76	0.80	0.74	0.77	6.12	0.04	0.31
200	75	4.4	4.69	4.88	4.66	10.78	0.23	0.54
230	63	4.3	4.24	4.14	4.23	15.00	0.21	0.75
270	53	4.19	4.08	4.19	4.15	19.16	0.21	0.96
pan	pan	0.84	0.73	0.58	0.72	19.87	0.04	1.00
					19.87			

Sieve #	Sieve, µ	Al2O3, avg.		
170	90	5.353333	Line equati	y = -0.3616x + 37.893
GS-250	87.86781	6.12	**GS-250**	**= 170 mesh API**
200	75	10.77667	**170 mesh**	**> 82.5 µ < 98 µ**

100	165	137.5			
Sieve, µ	Cum., g.		Test Screen Data	6.12	API Sceen
106	0.25				
90	5.353333		90	5.3533333	
0	6.12		75	10.776667	
75	10.77667				
63	15.00333		y = -0.3616x + 37.893		
53	19.15667				
pan	19.87333		**87.86781** µ		

y = -0.3616x + 37.893

Table #2 – Conductance Test Results

GS165-006	Screen Diameter	5.6605	inches	14.37767	cm
	Screen Thickness	0.52	mm	0.052	cm
30	Area of Screen	162.355325	cm2	25.16512407	in2
6/11/2009					

Avg. Temp, °F	Oil Density, lb/gal	Oil Height, inches	Oil Density, g/cc	Oil Visc., cP	Pressure Drop dynes/cm2	Pressure Drop psi	Mass Flow, kg/min	Volume Flow, cc/min	Perm-eability Darcy	Flow Rate, in3/sec	Flow Rate, in/sec
75.9496133	7.1	1.125	0.85	94.37	2383.10	0.03	1.71	2007.79	430.04	2.04	0.08
76.4208133	7.1	2.125	0.85	93.39	4501.41	0.07	3.10	3643.39	408.86	3.71	0.15
77.2268272	7.1	3.125	0.85	91.82	6619.72	0.10	4.64	5452.09	409.01	5.55	0.22

Average Permeability, Darcy	415.97
Avg. Permeability, Kilodarcys	0.42
Average Conductance, Kd/mm	**0.800**

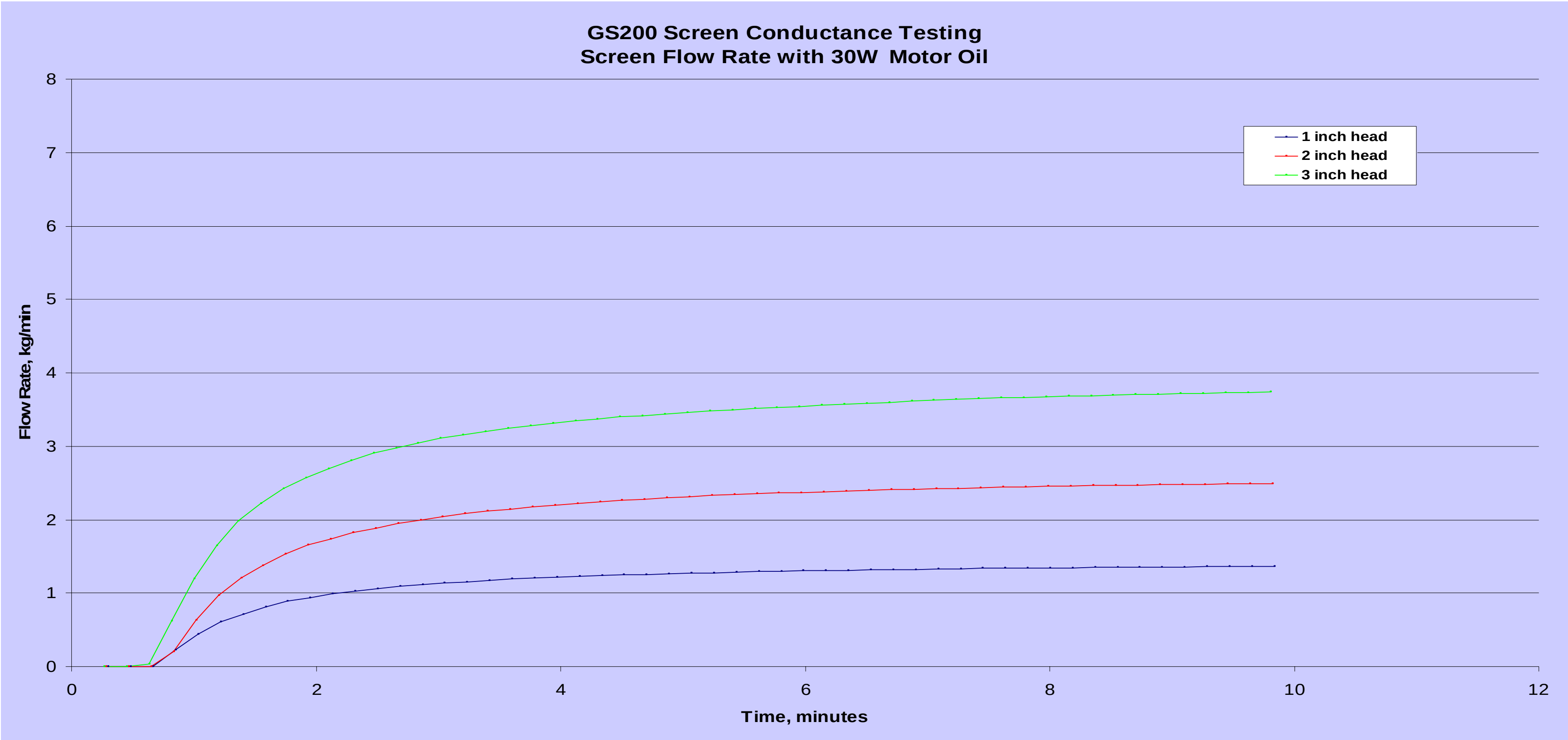
GS200-005

30w
6/11/2009

Screen Diameter	5.6605 inches	14.37767	cm
Screen Thickness	0.47 mm	0.047	cm
Area of Screen	162.355325 cm2	25.16512407	in2

Avg. Temp, °F	Oil Density, lb/gal	Oil Height, inches	Oil Density, g/cc	Oil Visc., cP	Pressure Drop dynes/cm2	Pressure Drop psi	Mass Flow, kg/min	Volume Flow, cc/min	Perm-eability Darcy	Flow Rate, in3/sec	Flow Rate, in/sec
73.7793774	7.1	1.125	0.85	99.37	2383.10	0.03	1.24	1462.63	298.15	1.49	0.06
74.5705946	7.1	2.125	0.85	97.45	4501.41	0.07	2.28	2678.52	283.48	2.72	0.11
75.3241233	7.1	3.125	0.85	95.73	6619.72	0.10	3.41	4002.30	282.94	4.07	0.16

Average Permeability, Darcy	288.19
Avg. Permeability, Kilodarcys	0.29
Average Conductance, Kd/mm	**0.61**



GS250-00004	Screen Diameter	5.6605	inches	14.378	cm
	Screen Thickness	0.47	mm	0.047	cm
30W	Area of Screen	162.355325	cm2	25.165	in2
6/11/2009					

Avg. Temp, °F	Oil Density, lb/gal	Oil Height, inches	Oil Density, g/cc	Oil Visc., cP	Pressure Drop dynes/cm2	Pressure Drop psi	Mass Flow, kg/min	Volume Flow, cc/min	Perm-eability Darcy	Flow Rate, in3/sec	Flow Rate, in/sec
68.9603494	7.11	1.125	0.85	113.43	2383.10	0.03	2.03	2384.33	554.78	2.43	0.10
70.6229146	7.1	2.125	0.85	108.11	4501.41	0.07	3.61	4239.36	497.77	4.31	0.17
72.5433919	7.1	3.125	0.85	102.59	6619.72	0.10	5.41	6364.17	482.14	6.47	0.26

Average Permeability, Darcy	511.57
Avg. Permeability, Kilodarcys	0.51
Average Conductance, Kd/mm	**1.09**