Drilling Technologies

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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 a shale shaker screen sieve and conductance test.

CONCLUSIONS

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

	ASTM	**Brandt Screen**
Sample	**API Screen**	**Conductance**
	Designation	**(Kd/mm)**
LIMS 150849	**120**	**1.267**

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 has 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 insure screen quality. 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 nitrogen.
4. After each test series, the screens were cleaned with soap and water, and then dried.

C. Aluminum Oxide Pre-sieving

All screen tests were conducted using AGA Bonded Standard Sands (aluminum oxide) certified as being at least 50% of the mess size stated on the bottle.

The test procedure for screen size determination is listed below. In order to conduct these tests efficiently, it is 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 by 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 is used in a test it is placed in a second set of marked weigh-boats and then re-sieved (as described above) prior to being used.

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 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) as follows:

    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 it 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 the 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 has been completed determine the average amount of weight retained on the test screen (S3). If the average amount is less than 10 weight percent (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 weight percent (4.5 grams) repeat the test using a one size finer screen designation for the test screen.

E. Calculations

1. Determine the amount of test material retain on each screen. Subtract the tare weight of the screen from the weight of the screen with the retained test material.
2. Calculate the amount of test material retained on both the test screen and the equivalent test screen. Determine the 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.
5. Determine the micron size of the test screen value.
6. Determine the API screen designation value based on the micron size of the test screen.

F. API Screen Designations

The following table summarizes the micron size ranges of various ASTM screens.

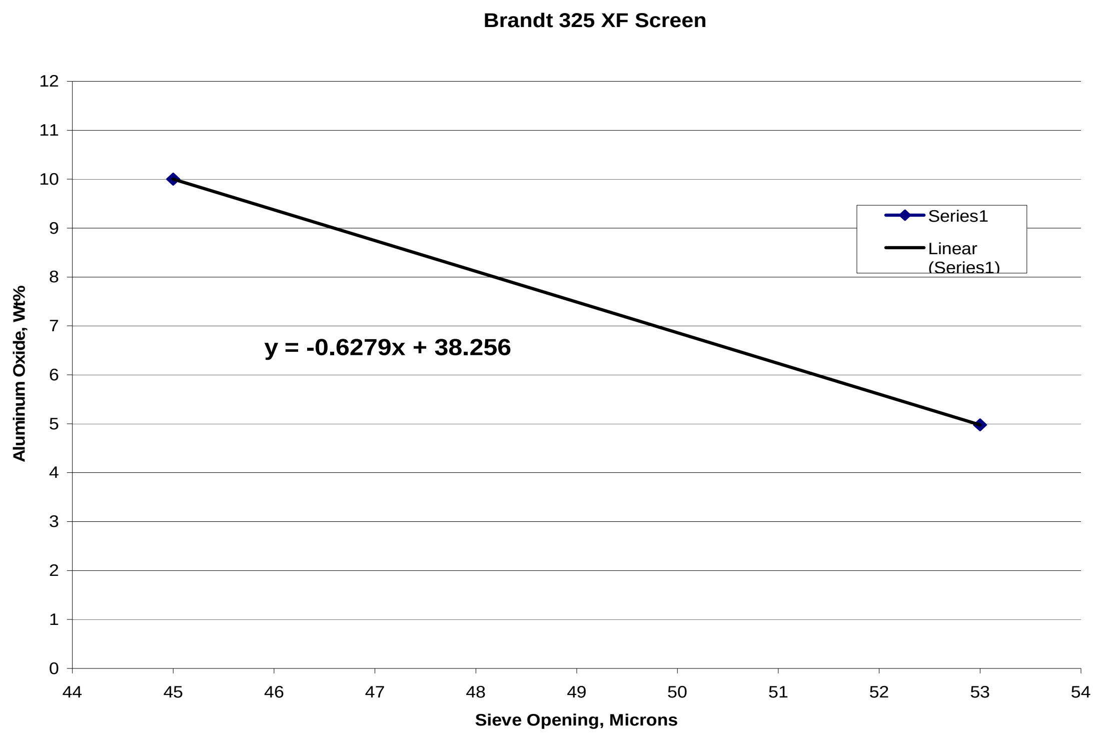
API Screen	Max., µ	Min., µ		API Screen	Max., µ	Min., µ
6	3675	3075		60	275	231
7	3075	2580		70	231	196
8	2580	2180		80	196	165
10	2180	1850		100	165	137.5
12	1850	1550		120	137.5	116.5
14	1550	1290		140	116.5	98
16	1290	1090		170	98	82.5
18	1090	925		200	82.5	69
20	925	780		230	69	58
25	780	655		270	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 screen had the following aluminum oxide sieve test result averages:

270 mesh (53 microns)	4.97 grams
Test Screen	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 linear regression equation is defined as:

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

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 the one-inch collar to screen ring (for 2 inch head).
12. Repeat test adding the two-inch collar to screen ring (for 3 inch head).
13. Download the data and enter it into conductivity calculation spreadsheet.

Conductivity Calculation Spreadsheet

1. The flow rate data for each test is graphed in order 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. The pressure drop in dynes is calculated by the equation: oil density (s.g.) * 980 * oil head height (inches)*2.54.
7. The pressure drop is converted to psi by multiplying dyne pressure drop by *1.4508*10^-5.
8. The 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. The 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. The volume flow rate, in cubic inches per second, is calculated by multiplying cc/min by 0.001017062.
11. The flow rate through the screen, in inches per second, is calculated by dividing volume flow rate by screen surface area.
12. The permeability, in Darcys, is converted to kilodarcies (Kd) by dividing by 1000.
13. The conductance, in Kd/mm, is calculated by dividing measured permeability by screen thickness, in mm.

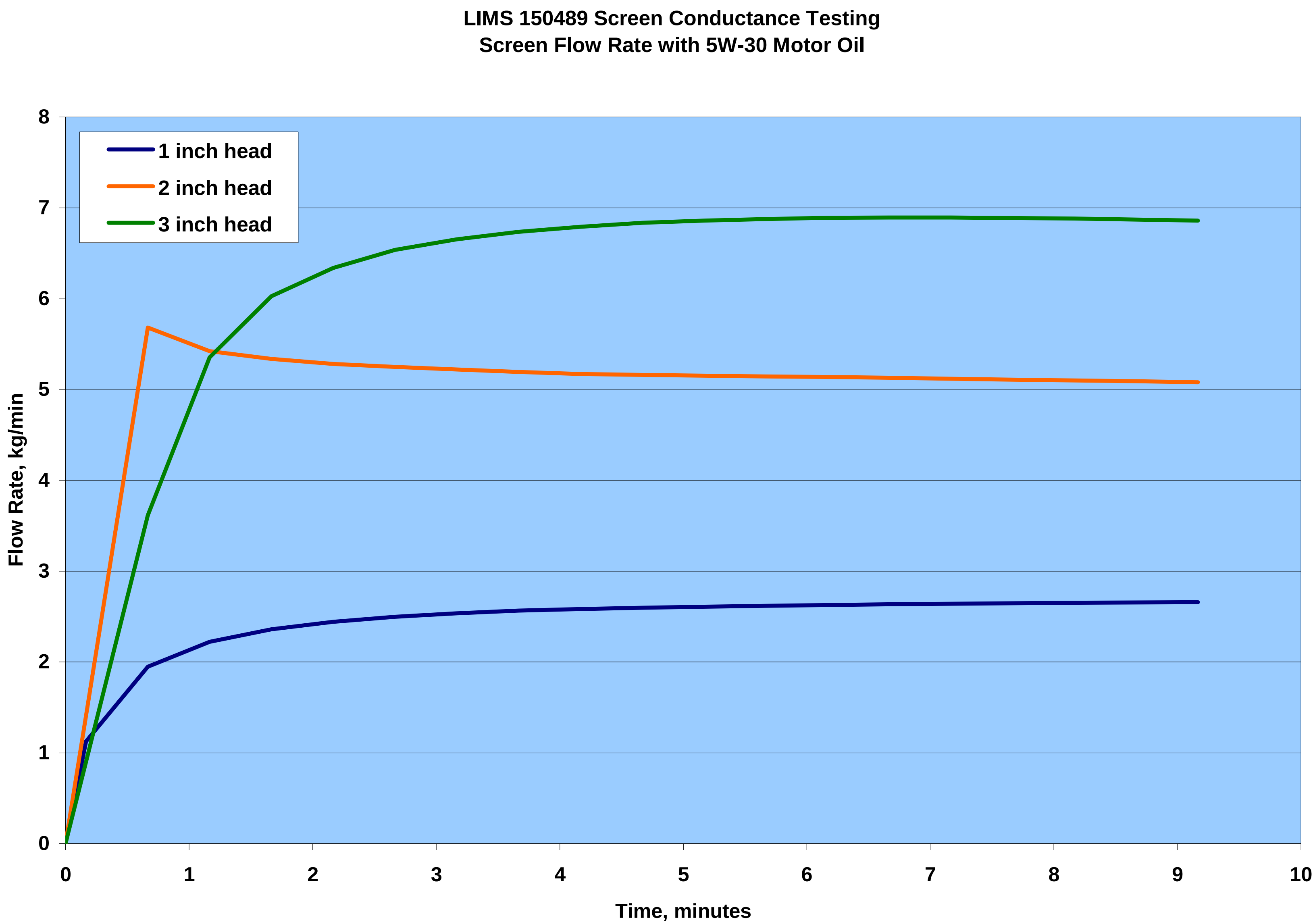
TEST RESULTS

Table #1
Screen Sieve Average Test Results

Sieve #		LIMS 150489						
					Test	**Average Test**	**Average**	**Cumulative**
Sieve	**Sieve**	**Test 1**	**Test 2**	**Test 3**	**Average**	**Cumulative**	**Retained**	**Retained**
(#)	**(µ)**	**(g)**	**(g)**	**(g)**	**(g)**	**(g)**	**(%)**	**(%)**
80	180	0.09	0.34	0.6	0.34	0.34	1.70%	1.70%
100	150	4.54	4.4	4.08	4.34	4.68	21.54%	23.25%
LIMS 150489		3.54	3.28	3.4	3.41	8.09	16.91%	40.16%
120	125	2.41	2.53	2.46	2.47	10.56	12.24%	52.40%
140	106	3.01	3.83	3.73	3.52	14.08	17.49%	69.89%
170	90	3.92	3.32	3.27	3.50	17.58	17.39%	87.28%
pan	pan	2.65	2.48	2.56	2.56	20.15	12.72%	100.00%
					20.15			
Sieve #	**Sieve**	**Average Al_2O_3**		Line equation	y = -0.2349x + 39.923			
	µ							
100	150	4.68						
LIMS 150489	135.5	8.09		**LIMS 150489**	**= 120 mesh API**			
120	125	10.56		**120 mesh**	**> 116.5 µ < 137.5 µ**			

Table #2
Conductance Test Results

Screen Name	**LIMS 150849**				**Screen Diameter**		**5.6100**	**inches**	**14.2494**	**cm**		
Manufacturer	**Global Wire Cloth**				**Screen Thickness**		**0.4**	**mm**	**0.04**	**cm**		
Type of Oil	**5W - 30**				**Area of Screen**		**159.47**	**cm^2**	**24.718**	**in^2**		
Test Date:	**9/2/2011**											
	Avg. Temp, °F	**Oil Density, lb/gal**	**Oil Height, inches**	**Oil Density, g/cc**	**Oil Viscosity, cP**	**Pressure Drop dynes/cm^2**	**Pressure Drop psi**	**Mass Flow, kg/min**	**Volume Flow, cc/min**	**Perm-eability Darcy**	**Flow Rate, in^3/sec**	**Flow Rate, in/sec**
Test 1	70.00	7.1	1.125	0.851	110.05	**2383.098**	0.035	2.30	2703.13	528.74	2.75	0.11
Test 2	70.00	7.1	2.125	0.851	110.05	**4501.407**	0.065	4.25	4999.66	517.74	5.08	0.21
Test 3	70.00	7.1	3.125	0.851	110.05	**6619.716**	0.096	5.99	7039.22	495.68	7.16	0.29
							Average Permeability, Darcy			**506.71**		
							Avg. Permeability, Kilodarcys			**0.507**		
							Average Conductance, Kd/mm			**1.267**		


LIMS 150489 Screen Conductance Testing
Screen Flow Rate with 5W-30 Motor Oil
1 inch head
2 inch head
3 inch head
Flow Rate, kg/min
Time, minutes
0
1
2
3
4
5
6
7
8
9
10